RADIO & TELEVISION NEWS

RADIO-ELECTRONIC Engineering

Trade Mark Registered U.S. Patent Office No. 432907

ELECTRONICS • COMMUNICATIONS • TELEVISION • RESEARCH • MAINTENANCE

SEPTEMBER, 1950

DEPARTMENTS

RADIO-ELECTRONIC ENGINEERING is published each month as a special edition in a limited number of copies of RADIO & TELEVISION NEWS, by the Ziff-Davis Publishing Company, 185 N. Wabash Avenue, Chicago 1, Illinois.

VOLUME 15, NUMBER 3, Copyright, 1950, Ziff-Davis Publishing Company

COVER PHOTO—Courtesy of Harley-Davidson Motor Co.

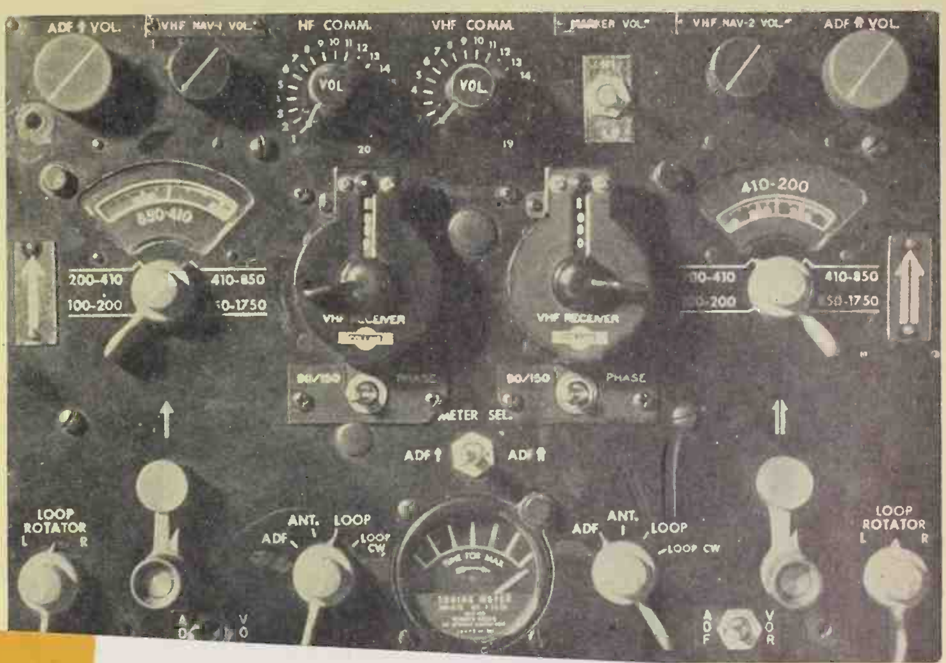
Victor Sierpinski, radio engineer at the Harley-Davidson Motor Co., Milwaukee, Wis. aligns the antenna circuit on the transmitter portion of the 2-way FM Motorola radiotelephone mounted on a police motorcycle. Over 500 police departments are using 2-way FM radiotelephone on motorcycles.

RADIO NAVIGATION EQUIPMENT

By

JOHN P. GRIFFIN

Northwest Airlines, Inc.



ONE of the most interesting of air navigation techniques is that employed in the use of VOR (Visual Omni-Directional Range) equipment. A pilot has merely to fly so that a meter needle, known as a Deviation Indicator, remains centered and he will head directly toward the station he is receiving or he will be flying away from the station on a radial he has chosen.

If his ship is equipped with an electronic autopilot he has only to flip a switch and enjoy automatic flight over any airway where VOR ground stations are installed. Upon approaching his destination, tuning the VOR receiver

r.

...arious

...ation.

...o patterns established ...rses. The patterns ...bed as essentially ...s is apparent from ...y resemble a pair ...ctor is designated ...ow and each has ...dulation: blue—90 ...ycles. This relation... all cases including ...me type of signal. ...dicating instrument

...t since no two quad... ...me combination of ...tification is possible.

the *A* to form a continuous tone and thus establish a course. These courses or legs, as they are more familiarly known, can be set at any convenient angular relationship to each other at the ground transmitter.

Inherent in this type of range are many disadvantages, prominent among which are the vagaries peculiar to low frequencies; atmospherics, night effect, bent beams, multiple courses, etc. Another and probably the most serious disadvantage is the time consuming and complicated procedure necessary for a lost pilot to orient himself. For example, a pilot receiving an *N* signal would

ADF needle, and using that bearing to fly toward the station. If he chooses, the pilot can head his airplane toward the nearest leg and fly that leg to the station.

In order to overcome these difficulties a new type of range was developed which utilized v.h.f. and which gave the pilot an immediate and unmistakable indication of his quadrant. It is known as VAR (Visual-Aural Range) and is so named because the signal from two of its courses is made to operate an indicator while the signal from the other two is aural.

...s was written only 70 visual-aural ranges were being operated by the CAA. The program was halted when it became apparent that the new type facility, VOR, had reached the practical stage of development.

Instead of just four range legs, the VOR station transmits a theoretically infinite number of radials, any one of which the pilot can choose to home on without the necessity of making bearing calculations. Moreover, he can maintain his heading with greater accuracy since the information can be presented

RADIO & TELEVISION NEWS

RADIO-ELECTRONIC Engineering

Trade Mark Registered U.S. Patent Office No. 432907

ELECTRONICS • COMMUNICATIONS • TELEVISION • RESEARCH • MAINTENANCE

SEPTEMBER, 1950

RADIO
Publishing Company,
Chicago 1, Illinois.

VOLUME 15, NUMBER 3, Copyright, 1950, Ziff-Davis Publishing Company

COVER PHOTO—Courtesy of Harley-Davidson Motor Co.

Victor Sierpinski, radio engineer at the Harley-Davidson Motor Co., Milwaukee, Wis. aligns the antenna circuit on the transmitter portion of the 2-way FM Motorola radiotelephone mounted on a police motorcycle. Over 500 police departments are using 2-way FM radiotelephone on motorcycles.

ZIFF-DAVIS PUBLISHING COMPANY

RADIO NAVIGATION EQUIPMENT

By

JOHN P. GRIFFIN

Northwest Airlines, Inc.

ONE of the most interesting of air navigation techniques is that employed in the use of VOR (Visual Omni-Directional Range) equipment. A pilot has merely to fly so that a meter needle, known as a Deviation Indicator, remains centered and he will head directly toward the station he is receiving or he will be flying away from the station on a radial he has chosen.

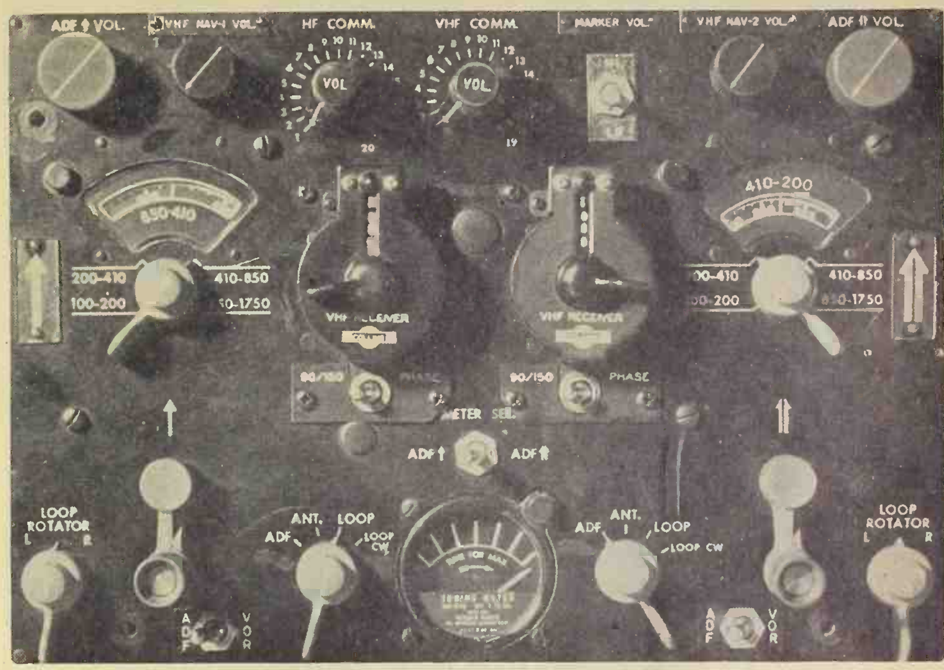
If his ship is equipped with an electronic autopilot he has only to flip a switch and enjoy automatic flight over any airway where VOR ground stations are installed. Upon approaching his destination, tuning the VOR receiver to the local ILS (Instrument Landing System) station will supply signals to the autopilot which will bring the ship down through the heaviest overcast, in line with the runway and at the correct glide angle for a perfect landing.

Visual Omni Range stations are rapidly being commissioned and eventually will replace the four course high frequency range now in general use throughout this country.

For the sake of a foundation upon which to build a discussion of VOR, let us review the principles involved in the presently used h.f. range system.

The radiation pattern transmitted by an h.f. range station consists of four quadrants, each identified by continual transmission of either the letter *A* or *N* in code. As shown in the sketch in Fig. 2A, adjacent quadrants are identified by different letters. Down the center line of the overlap zone the dash-dot of the *N* blends with the dot-dash of the *A* to form a continuous tone and thus establish a course. These courses or legs, as they are more familiarly known, can be set at any convenient angular relationship to each other at the ground transmitter.

Inherent in this type of range are many disadvantages, prominent among which are the vagaries peculiar to low frequencies; atmospherics, night effect, bent beams, multiple courses, etc. Another and probably the most serious disadvantage is the time consuming and complicated procedure necessary for a lost pilot to orient himself. For example, a pilot receiving an *N* signal would have no way of immediately determining which of the *N* quadrants he is flying in.



Radio control panel with the VOR selectors in the center.

Part 1 of a 2-part article discussing various electronic equipment used in air navigation.

A pilot in an airplane equipped with ADF (Automatic Direction Finding) would find his bearing indicator needle pointing toward the station and he could fly toward the station merely by following the needle (homing). His track over the ground, however, would be influenced by cross wind and would not necessarily be a straight line. He could fly a more direct route to the station by rotating the compass card on his ADF indicator, noting his bearing to the station as indicated by the ADF needle, and using that bearing to fly toward the station. If he chooses, the pilot can head his airplane toward the nearest leg and fly that leg to the station.

In order to overcome these difficulties a new type of range was developed which utilized v.h.f. and which gave the pilot an immediate and unmistakable indication of his quadrant. It is known as VAR (Visual-Aural Range) and is so named because the signal from two of its courses is made to operate an indicator while the signal from the other two is aural.

Overlapping of two patterns establishes the visual courses. The patterns are frequently described as essentially cardioid shaped but as is apparent from Fig. 2B, more closely resemble a pair of kidneys. One sector is designated blue, the other yellow and each has a characteristic modulation: blue—90 cycles, yellow—150 cycles. This relationship is maintained in all cases including ILS which is the same type of signal. In fact the same indicating instrument is used for both.

Fig. 2C shows that since no two quadrants give the same combination of signals, instant identification is possible.

At the time this was written only 70 visual-aural ranges were being operated by the CAA. The program was halted when it became apparent that the new type facility, VOR, had reached the practical stage of development.

Instead of just four range legs, the VOR station transmits a theoretically infinite number of radials, any one of which the pilot can choose to home on without the necessity of making bearing calculations. Moreover, he can maintain his heading with greater accuracy since the information can be presented

VOR installation in NWA aircraft showing ADF receivers on lower shelf.

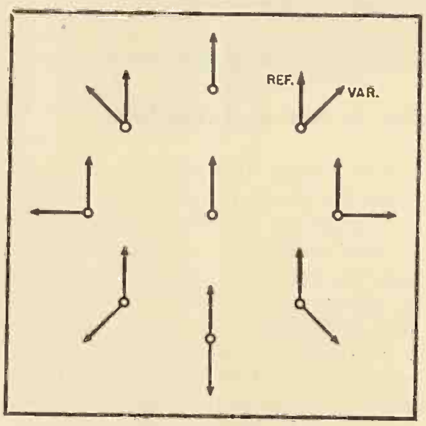


Fig. 1. Vectors of the reference and variable signals.

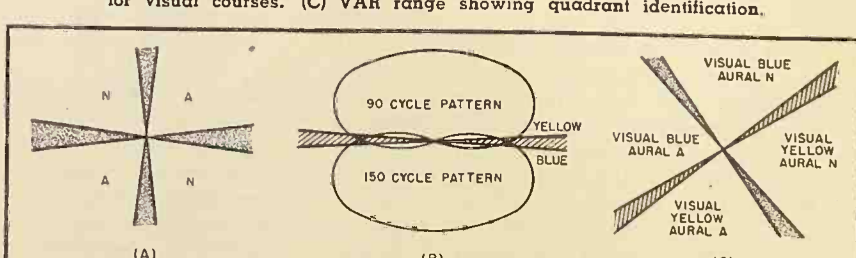
on the ILS deviation indicator whose needle movement is large for small changes in aircraft position.

In addition to the ILS deviation (cross pointer) indicator, the modern airplane is equipped with a Master Direction Indicator (MDI), a flux gate or valve for sensing the airplane's position relative to the earth's magnetic field, and a dual ADF system.

As is evident from Fig. 7 the RMI (Radio Magnetic Indicator) has two needles and a rotatable compass card. During the interim period between nation-wide installation of VOR stations and the decommissioning of h.f. ranges, the RMI needles in most installations are switchable from VOR to ADF. The RMI card is driven by amplified signals from the flux valve and therefore presents information about the airplane's heading relative to magnetic north. Presentation of VOR information on the ILS deviation indicator is accomplished by other switching arrangements.

The VOR ground station in effect transmits an infinite number of radials, any one of which can be selected by the pilot and flown by means of the vertical pointer on the ILS deviation indicator. Although the present four course range can be flown in a similar manner by homing on the ADF needle, the deviation indicator presents a more accurate indication of deviation and can be used as a vernier supplementing the ADF type of information.

Fig. 2. (A) Four course high frequency range. (B) Radiation pattern for visual courses. (C) VAR range showing quadrant identification.



Transmitted Signal

A pair of antennas—whose radiation pattern when energized in phase opposition simultaneously is a figure eight —is fed by a transmitter through a goniometer (1800 r.p.m. motor-driven capacitor).

As a result of the constant change of capacity, a pattern builds up and decays 30 times per second. Another pair of antennas situated at right angles to the first pair sets up a similar pulsating pattern but with a 90 degree phase difference. The revolving capacitors are driven by the same shaft and are fixed 90 degrees apart circularly.

Rotation of the goniometer has the following effect: When the field due to one pair of antennas is maximum, the field from the other is minimum. When one field begins to decay, the other begins to build up. The fields are additive and will always produce a resultant field whose position will be dependent upon the relative magnitude of its components.

At the position where one field begins to decay and the other begins to build up, Fig. 5C, the slightly less than maximum number one field adds to the slightly more than minimum number 2 field and the resultant is a maximum field a few degrees displaced from the starting point, Fig. 5D.

For each decrease in one and increase in the other there occurs a proportional rotation of the resultant figure eight field. The over-all result is a single figure eight field rotating at 30 c.p.s. (1800 r.p.m.).

A fifth antenna is placed equidistant from the other four and is made to radiate a non-directional pattern. Since the two lobes of the figure eight pattern are opposite in phase, one of them will be in phase with the non-directional pattern and additive, the other will be out of phase and subtractive, Fig. 5E. One lobe will thereby be enlarged and the other reduced. The resultant pattern will approximate a revolving cardioid, Fig. 5F.

Transmission Principles

A receiving antenna at any point within the range of the transmitter would be energized with a 30 c.p.s. voltage varying sinusoidally from zero to maximum to zero with each sweep of the revolving field. Assume there is a 30 c.p.s. oscillator at the receiver and in phase with the receiver antenna voltage. The frequency of the oscillator remains fixed and if the receiver is moved in any direction other than to or from the transmitter, there will occur a shift in phase between the oscillator frequency and the frequency of the receiver antenna voltage. This is so because the receiver and its antenna have moved to a point where the revolving pattern encounters the antenna and starts a cycle either sooner or later, depending on which direction the receiver and its antenna were moved. The phase of the 10 kc. carrier does not vary with azimuth. If this phase difference were made to operate a zero center deviation indicator, then movement on any path other than toward or away from the transmitter would result in a needle deflection either to the right or to the left of zero. As long as the indicator needle reads zero the path is either to or from the transmitter.

Instead of a fixed oscillator at the receiver, the non-directional center antenna transmits a fixed 30 c.p.s. voltage, called Reference Voltage, which is used for comparison with the induced antenna voltage, called Variable Voltage, Fig. 1.

In order to accomplish separation of the two signals at the receiver, the 10 kc. signal (actually 9960 cycles) which the center antenna radiates, is frequency modulated with the 30 cycle reference voltage. When the rotating pattern reaches north, the 10 kc. signal starts a new cycle. Thus the relation—the phase separation—between the two signals at any one point around the transmitter remains fixed. The receiver has then only to separate a frequency modulated signal from an amplitude modulated signal. In order to retain the advantages of v.h.f. and avoid the necessity of having two r.f. sections in the receiver, the 10 kc. signal is not a carrier in itself but modulates the amplitude of a v.h.f. carrier 30 per-cent. The v.h.f. carrier can also be modulated 30 per-cent by voice.

Fig. 3 shows the Omni-Bearing Selector. The figures in the window of the Selector are set up by the knob on the right. These figures indicate the selected track—the ship's bearing from the station. If the figures in the window read zero and the ship is on radial 315 there will be a phase difference between the reference and variable signals of 315 degrees. By turning the knob, the phase shift can be reduced to zero and the figures in the window will then indicate through what angle the variable phase had to be shifted in order to reduce the difference to zero. If the deviation indicator is connected to the receiver output it will now be centered and will remain so as long as the selected radial is flown. Any needle position to the left of zero indicates that the airplane has to be flown to the left to return to its course.

During the time of flight to the station, the TO-FROM indicator on the Omni-Bearing Selector remains in the TO position. Upon passing over the station it changes to FROM thereby acting as a marker. If now the airplane is turned and headed back to the station on the same radial, the heading will become the reciprocal of 315. By turning the knob on the left of the Omni-Bearing Selector, the window openings will change and 135, the reciprocal, will appear. The action of changing the window also reverses the connections to the TO-FROM indicator which will then read TO. Connections to the deviation indicator are also reversed and sensing remains normal.

Fig. 7 illustrates the Radio Magnetic Indicator. This instrument operates in a manner identical to the ADF indicator except that the magnetic scale card instead of being adjusted by hand is automatically and continuously adjusted by means of amplified signals from the flux gate. Thus magnetic bearing is continuously available. By utilizing a switch on the radio control panel, either the single or double pointer needles can be connected to either VOR or ADF. The illustration depicts a condition in which the double pointer needle is being actuated by the signal from a station whose magnetic bearing from the aircraft is 206 degrees. The bearing of the aircraft from the station is the reciprocal, 26 degrees. In other words, the aircraft is north-northeast of the station. The heading of the aircraft as read at the top of the dial is 256 degrees.

Fig. 3. Omni-Bearing Selector.

With the equipment described, it would only be possible to obtain a fix by triangulation and then only if two or more stations could be received. Distance Measuring Equipment (DME), now in the process of development, will present to the pilot a simple meter indication of his distance from a selected ground station with an ac-

(*Continued on page* 29A)

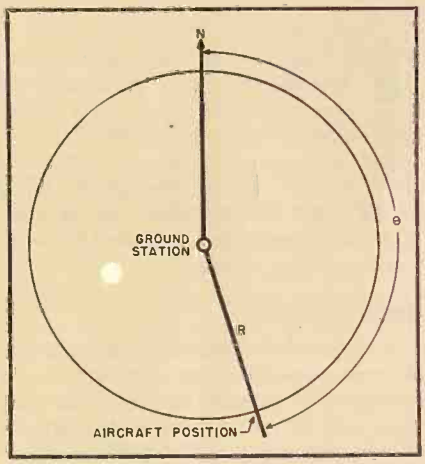
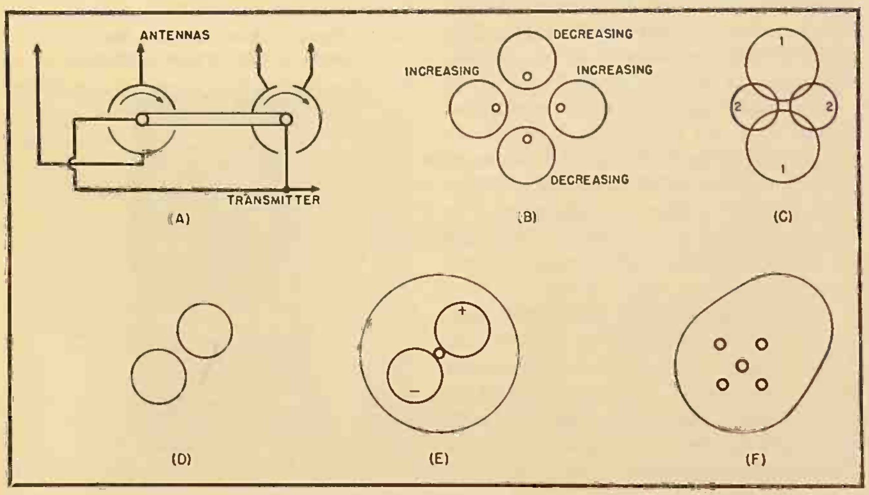


Fig. 4. R-Theta information.

Fig. 5. (A) and (B) Goniometer and its effect on radiation pattern. (C) No. 1 field decreasing, No. 2 increasing. (D) Resultant field, displaced. (E) Another field added by center antenna. (F) Resultant field.



TV Impulse Interference Generator

By JOHN D. FOGARTY

Senior Engineer, Research Div., Philco Corp.

A device for generating controllable impulse noise for simulating action of ignition noise on TV sets.

THE purpose of the equipment described in this paper is to generate controllable impulse noise which will simulate the action of ignition and other such impulse noise on television sets. Its use enables comparative tests to be made of the effects of varying amounts of noise on different types of synchronizing circuits.

Introduction

Using the Television Impulse Interference Generator, an impulse can be placed anywhere in the television picture and in the synchronizing regions. Pulses are made in a vertical group of variable length, one pulse per line recurring on each successive line for the duration of the group. The pulses occur one below the other; that is, the horizontal positioning of each pulse is the same on every line. The group length can be varied from 1 to 150 pulses. The pulse groups recur once every frame; that is, on alternate fields.

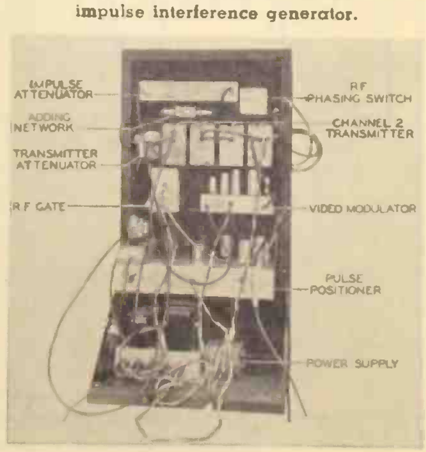
The amplitude of the transmitted signal and the noise impulses can be controlled independently. The phase of the r.f. carrier of the impulse envelope with respect to the transmitter carrier can be adjusted so that the impulses add or subtract from the signal, thereby creating black or white noise.

It is known that the frequency spectrum of man-made impulse noise is continuous up to at least 600 megacycles. Since a television receiver has a bandpass of about six megacycles, it is only necessary for the impulse noise to have frequency components within its passband. In this generator, the noise impulse consists of a burst of r.f. carrier 0.1 microsecond in duration. A pulse of this width is beyond the resolving power of the receiver, and so produces an action similar to that of a noise spike.

In this device, the noise impulse is generated by putting part of the video carrier through a gated amplifier and then feeding it into the receiver input through an attenuator and a phasing control. The transmitter is fixed-tuned to Channel 2 only, because the receiver's action on one channel is indicative of its response to noise on the other channels.

Since only Channel 2 carrier is used for the impulse noise, the r.f. phase of the carrier burst with respect to the transmitter carrier is controlled by inserting different lengths of delay line between the gated amplifier and the mixing box.

Fig. 1. Rear view of the TV impulse interference generator.



Description of Units

Rear and front views of the interference generator are shown in Figs. 1 and 6; Figs. 2 and 3 show simplified block diagrams of the equipment.

a. Television Transmitter

The television transmitter used in this equipment was originally a crystal controlled r.f. section built for Channel 1, but was modified as a self-controlled unit tuned to Channel 2. It contains a self-controlled oscillator feeding a buffer amplifier. Part of the output of the buffer amplifier is fed to the final video stage and part of it goes to the gated amplifier which generates the impulse bursts. After the final video amplifier there is a step attenuator for varying the output of the transmitter.

The transmitter contains a final audio amplifier to generate a sound carrier. The use of the sound carrier in this equipment is simply to aid in tuning the receiver being tested or to hold the automatic frequency control if the receiver has one.

b. The Modulator

The equipment contains a video modulator for use with the television transmitter. This modulator unit contains video amplifiers, and the percentage-modulation and black level controls. The modulator is fed with a composite video signal of one volt peak-to-peak with the sync down. This signal can be obtained from the laboratory line or from the output of another receiver operating on an air signal.

c. R.F. Gate

The r.f. gate provides the pulse and is a grounded-grid amplifier with the grid biased below cut-off. The carrier r.f. from the transmitter is fed into the cathode of the gated amplifier which is biased much beyond tube cut-off, and the 0.1 microsecond trigger pulse is applied to the grid to raise the tube to conduction. The output circuit of the gated amplifier is a heavily-damped tuned circuit whose bandpass is about 15 megacycles between half-power points. The gate output is a 70-ohm coaxial line. The output line which goes to the impulse attenuator is a long coaxial line cut so that the r.f. phase comes out properly.

d. Impulse Attenuator

This attenuator is built of resistive T-sections which can be switched in and out by means of toggle switches. A total of 80 db. of attenuation is available in one db. steps.

e. R.F. Phasing Switch

This is a three-position switch and in the zero-degree position the circuit is straight through the switch. Carrier bursts from the r.f. gate go through the length of line into the attenuator, and are impressed on the carrier of the transmitter. By turning this switch, a quarter- or half-wave length of coaxial line may be connected into the gate output. This enables one to vary the r.f. phase relationship between the carrier bursts and the transmitter carrier from zero degrees to 90 degrees and to 180 degrees. Hence, in-phase and out-of-phase impulses can be generated, giving black or white impulse noise, depending also on the amplitude of the impulse with relation to the transmitted signal. The transmitter picture signal and the burst of impulse noise are added together in a resistive adding network which provides a 70-ohm coaxial output to the receiver on test.

f. Pulse Positioner

The composite video signal used with this apparatus is also fed into the pulse positioner. Here it passes through several video amplifier stages into a sync separator stage of the same type that is used on conventional receivers. See the block diagram in Fig. 5 and the waveforms shown in Fig. 4. The horizontal synchronizing pulses from the sync separator go through a horizontal blocking oscillator. The vertical sync pulses from the sync separator go through a relaxation oscillator, which is here called the vertical pulse alternator, because it only fires on every other one of the vertical pulses. This vertical alternation enables the impulse group to be put on every frame, that is, on alternate fields. The vertical timing pulses from the vertical alternator go into a cathode-coupled multivibrator which is used for the vertical positioning of the group. These timing pulses trigger the cathode-coupled multivibrator, which in turn produces an output pulse a variable length of time afterwards. This timing pulse next goes into the group-length multivibrator, another cathode-coupled multivibrator whose output is in the form of a pedestal with a variable length, starting when the output of the vertical positioning multivibrator hits the next stage.

Let us now consider the horizontal sync pulses. After coming through the blocking oscillator, the output pulses next go into another cathode-coupled multivibrator which provides a continuously variable delay from about 10 to 15 microseconds up to 40 microseconds so that they can cover about half the picture width. There is also available another fixed multivibrator which provides about half a line of delay. By use of these two delaying multivibrators, the pulse group can be positioned anywhere horizontally on the picture and through the horizontal sync

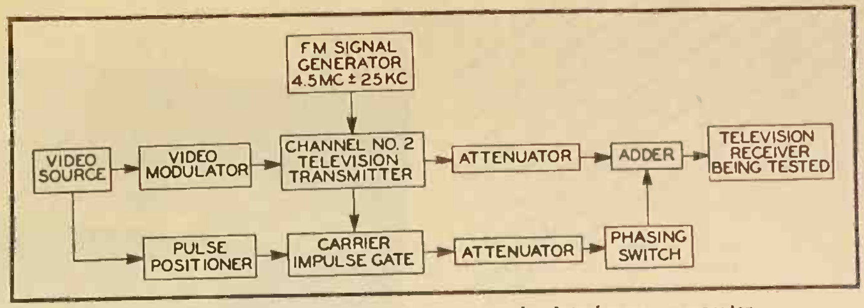


Fig. 2. Block diagram of the television impulse interference generator.

region of the transmitted signal. These delayed horizontal pulses and the vertical group-length pedestal are both fed into the group-length gate tube whose output consists of the horizontal timing pulses, a group of pulses coming out whenever the group-length pedestal is applied to the gate. This group of timing pulses is then amplified through a trigger amplifier and is applied to the pulser stage. This is simply a thyratron line-driven pulser which provides the 0.1 microsecond triggering pulse for use by the r.f. gate. Thus, the pulse positioner unit provides the 0.1 microsecond triggering pulses to the carrier burst gate in such a way that the impulses can be positioned on the picture of the television set being tested.

g. Power Supply

A standard laboratory power supply is used that provides 250 volts of B+ voltage which is regulated and —30 volts of bias voltage which is not regulated. The plate current drawn by the entire interference generator is about 175 milliamperes.

Operation

A composite video signal is required to run the transmitter modulator and to provide timing pulses for the pulse positioner operation. This video signal should be one volt peak-to-peak with the sync down. This can be obtained from the laboratory line or from the output of another television receiver which is picking up a signal off the air.

A *Boonton* FM signal generator was employed to provide sound carrier for the transmitter, because 0.7 volt output at 4.5 megacycles (± 25 kc.) could be obtained with 400 cycle modulation.

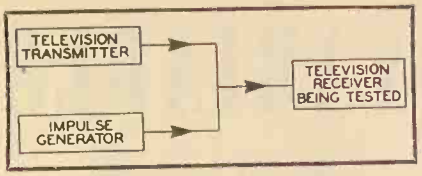


Fig. 3. Simplified diagram of operation.

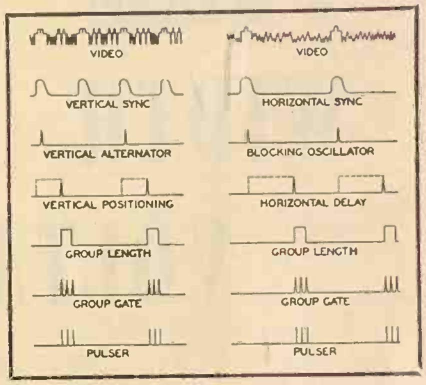


Fig. 4. Pulse Positioner waveforms.

The impulse interference generator is connected to the receiver on test by a 70-ohm coaxial line. For receivers having a 300-ohm balanced line input, a half-wave coaxial matching transformer may be used.

After power supply adjustments have been made, the next step is the adjustment of the transmitter and modulator. The transmitter output depends on the setting of the ladder attenuator on the front of the transmitter panel and upon the adjustment of the black level voltage to the modulator. The peak amplitude of the sync pulses is held constant in the transmitted signal. A percentage

(*Continued on page* 28A)

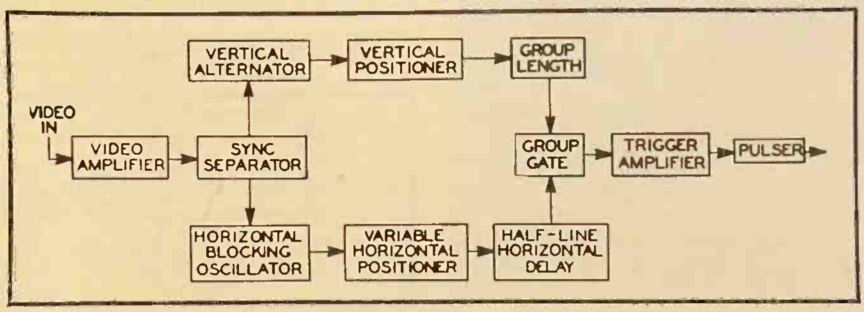
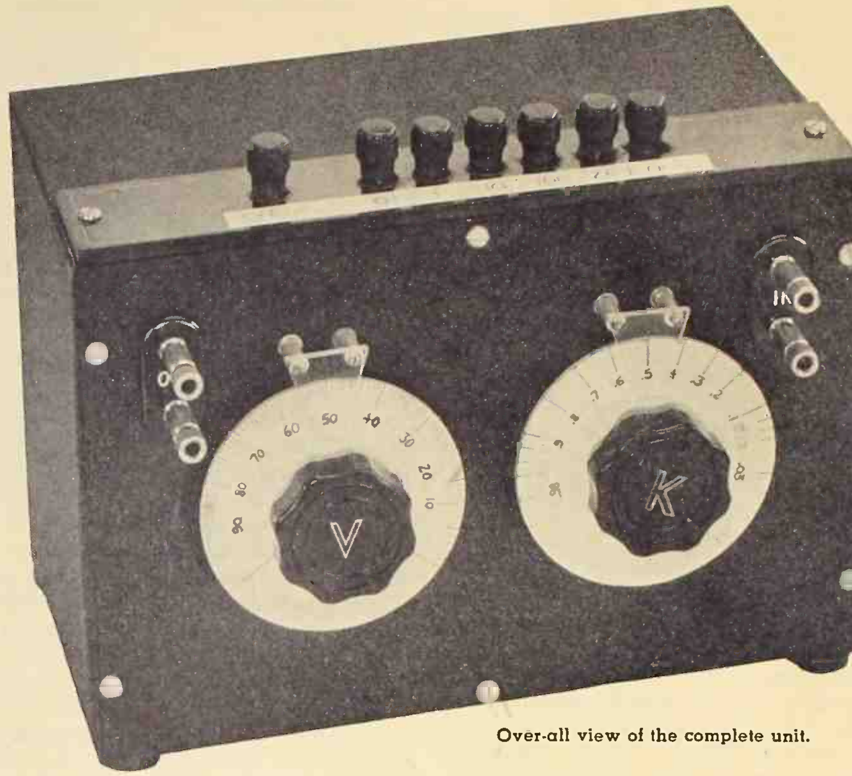


Fig. 5. Block diagram showing components of the pulse positioner.

VARIABLE PULSE WIDTH VOLTAGE CALIBRATOR



Over-all view of the complete unit.

By **RALPH H. BAER,** Chief Engineer
Wappler, Inc., New York

This unit provides an output of variable amplitude and adjustable zero reference line for calibrating oscilloscopes.

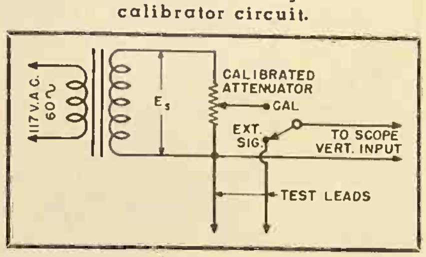
EFFECTIVE laboratory and production use of cathode-ray oscilloscopes generally calls for the employment of accessory devices in considerable numbers. Low-capacity probes, time marker generators for x-and z-axis calibration, peak limiters and voltage calibrators are familiar examples of such instruments. Of these the voltage calibrator is the most indispensable aid in the development and production testing of electronic equipment. The calibrator effectively converts the oscilloscope into a high-impedance voltmeter capable of accurate quantitative measurements over wide amplitude ranges and irrespective of waveform.

Basically, voltage calibrators provide a signal of variable amplitude which may be substituted for the signal under investigation and adjusted for identical peak-to-peak deflection on the CRT screen. Calibrated attenuators or meters then provide a direct indication of the signal amplitude. An elementary type of voltage calibrator may take the form of Fig. 1. Power line frequency sine wave signals and a potentiometer calibrated in fractions of E_s are substituted for the waveform under observation. A practical version of this circuit is shown in Fig. 3. Calibrations will hold for any oscilloscope with an input impedance exceeding one megohm. The instrument is initially calibrated by varying R_1 and R_2 with switch S_1 in the 500 v. and 1 v. positions respectively.

Simple calibration instruments of the type described above suffer from two practical disadvantages: lack of accuracy due to line voltage variations and alignment ambiguity. Due to the low rate of amplitude change of a sine wave near its maximum excursions it is difficult to line up the calibrating signal peaks with the desired horizontal lines on the transparent coordinate grid customarily attached to the CRT screen. For this reason commercial calibrators deliver square waves or flat-topped, clipped sine waves. In addition, some stable voltage reference such as a gaseous VR tube is used to maintain the initial calibration independent of line-voltage changes. A circuit of this type is shown in Fig. 4. In this arrangement the sinusoidal signal applied to the attenuator is limited on both peaks to a value equal to one-half the VR operating voltage. R_4 is selected to give some convenient peak-to-peak voltage value for the maximum range which lends itself to simple decimal reduction by means of the attenuator switch S_1.

A convenient procedure for rapid measurements with calibrators of the symmetrical square wave type is the preadjustment of the oscilloscope gain controls to yield a suitable unit deflection per scale division. For example,

Fig. 1. Basic voltage calibrator circuit.



if it is expected that signals of less than 100 volts peak-to-peak amplitude will be encountered, the voltage calibrator would be set to the 100-volt range and the oscilloscope trace adjusted until its maximum excursions coincided with two horizontal reference lines on the coordinate scale. After this the gain controls are left in place and signal amplitude determined from the number of grid subdivisions between peaks. This method works out very well whenever the effects of minor adjustments on the scope waveform are studied or when signals of the same order of magnitude are involved. Measurements are then reduced to an adjustment of the vertical centering control to position the trace with respect to the grid so as to permit quick interpolation.

For many oscilloscope applications this procedure is inadequate; on one hand widely varying signal levels are usually encountered as different portions of the equipment or individual circuit are approached; on the other hand, visual interpolation between grid lines does not particularly lend itself to accuracy. Furthermore, any vertical nonlinearity of the oscilloscope introduces an additional error into the measurement. A direct comparison method will lead to greater precision. Switching from the signal being scoped to the voltage calibrator and adjusting the latter for identical peak-to-peak amplitude makes it possible to read the signal level directly from the calibrated attenuator without possibility of error. In pulse circuit development this direct comparison method is frequently found most convenient as the test probe is moved from point to point in a physical circuit layout. Even when variations in waveshape or level at the same point are being studied where these changes are of a minor order of amplitude, the necessity for maintaining large screen deflection to obtain readable patterns of small detail means continuous readjustment of the vertical gain control. The use of the precalibration method is, therefore, automatically precluded. A new difficulty now arises. Dissimilarity of signal and calibrator waveforms necessitates the adjustment of the vertical centering control each time the calibrator is switched to the oscilloscope input, and once more when the latter is switched back to the signal under test. This condition results from the axial dissymmetry of most pulse waveforms, resulting in the familiar baseline shift common to all oscilloscopes using resistance-capacitance coupling in the vertical amplifier. It will be remembered that this effect is due to the fundamental requirement that the current into a coupling condenser such as that shown in Fig. 2A must equal

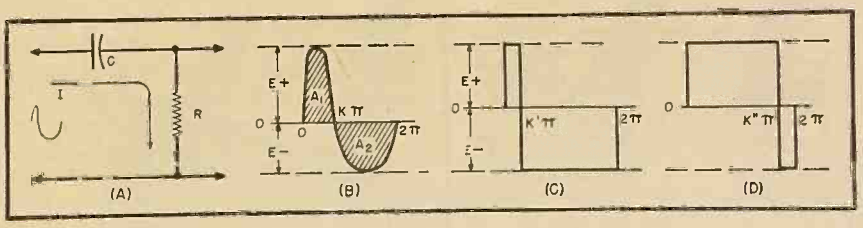


Fig. 2. Baseline shift of assymetrical waveform (B) after passing through R-C network (A). Waveforms in (C) and (D) will produce opposite baseline shifts which are proportional to K.

the current out of the condenser, averaged over each complete cycle. Hence the quantity of charge and discharge Q must also be zero. But:

$$Q = \frac{1}{C} \int I dt \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Since the integration indicates area under the curve it follows that areas A_1 and A_2 must be equal in order to prevent a residual charge on C at the termination of a cycle. Hence, from Fig. 2B:

$$\frac{1}{C} \int_0^{K\pi} I dt = \frac{1}{C} \int_{K\pi}^{2\pi} I\,dt \quad . \quad . \quad (2)$$

For nonsinusoidal signals Eqt. (2) can be true only if the current under the integral signs are different functions of time. Furthermore, if they are not symmetrical, their peak amplitudes $E+$ and $E-$ must be different and, in general, periods $0 - K\pi$ and $K\pi - 2\pi$ will not be equal. This suggests the use of a pulse waveform for voltage calibrators in which the sum of the positive and negative excusions $E+$ and $E-$ is constant but K is continuously variable as in Fig. 2C and D; to provide a high degree of practical utility it should be possible to vary K over wide limits. If the pulses have steep sides and flat tops it can be shown that the baseline shift is directly proportional to K. Hence, in order to produce upward or downward shifts of 90% of the peak-to-peak value (to compensate, for example, for the pattern displacement by a waveform consisting of a narrow exponential pulse), K must be capable of a 45:1 variation, both positively and negatively. With a voltage calibrator generating a pulse of this waveform, the calibrator output is adjusted for proper amplitude and shifted vertically by varying K, without necessitating the continuous readjustment of the oscilloscope centering control. In addition, calibrating the variable element producing the baseline shift directly in terms of K enables one to determine at a glance the relative amplitude of positive and negative excursions of any signal. This makes it immediately possible to determine the actual amplitude of either the positive or negative pulse with respect to zero reference

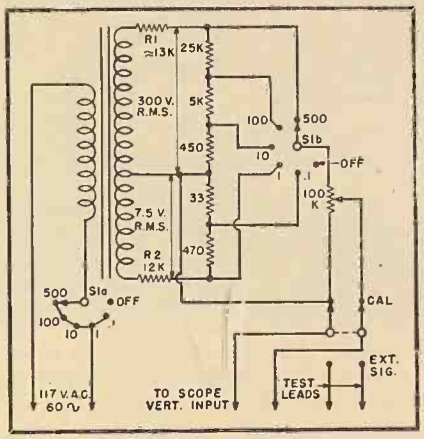


Fig. 3. Practical form of powerline frequency sine wave voltage calibrator with 500 v. max. peak-to-peak range.

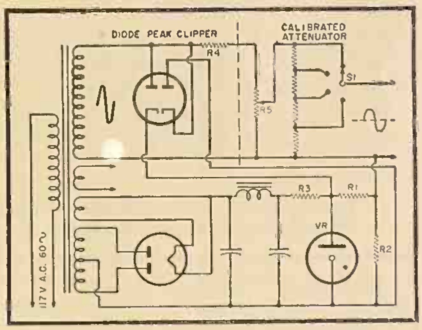
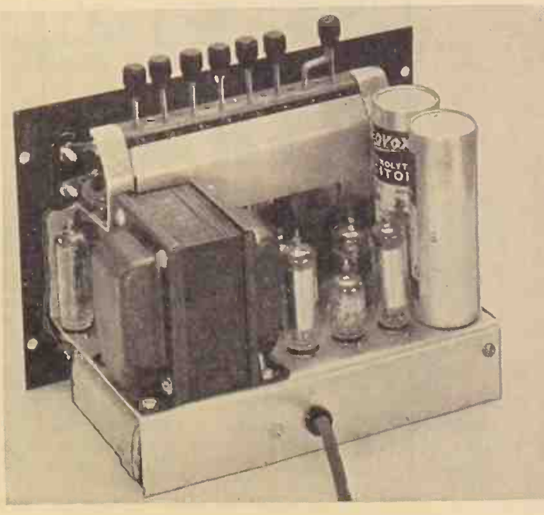


Fig. 4. Voltage-stabilized calibrator circuit for generating clipped sine waves.

Top rear view of calibrator.



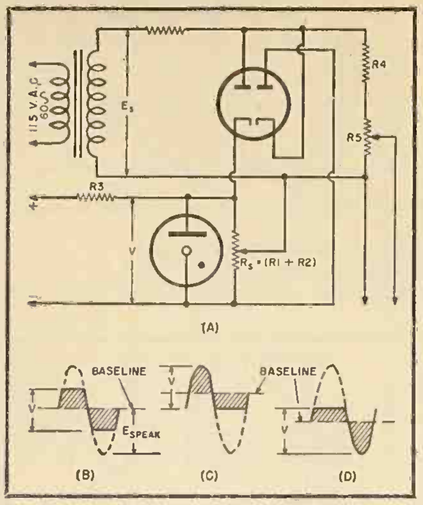


Fig. 5. Clipped sine wave generator (A) and output waveforms for (B) central setting of R_s and (C and D) for extreme settings of R_s.

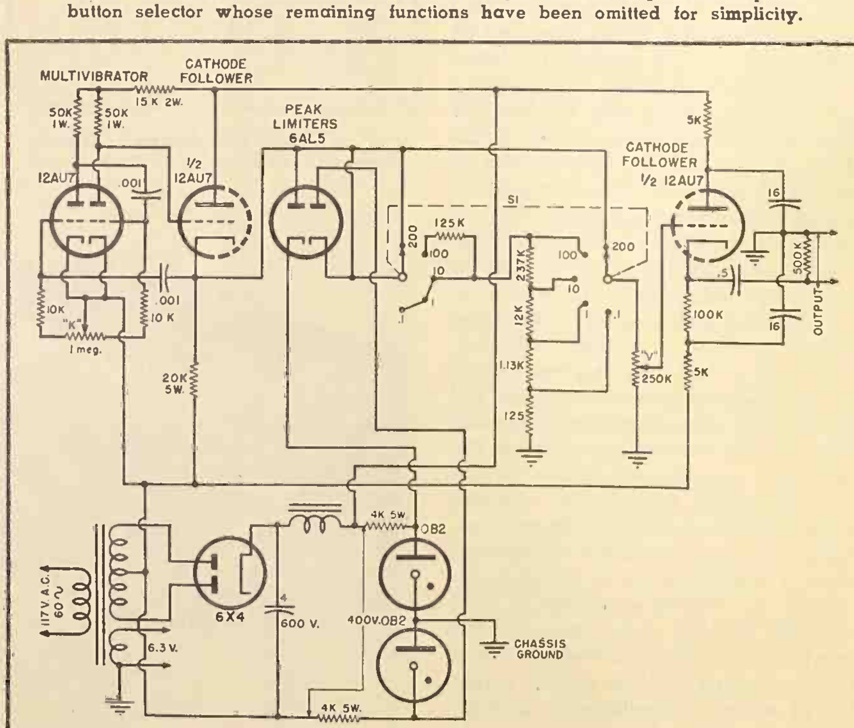
level, whichever may be of interest in the particular circuit application. For example, if a steep-sided pulse is to be positively peak-limited, used to synchronize a multivibrator, differentiated to produce a positive trigger, etc., the maximum positive amplitude is of more interest than the peak-to-peak value. The shift-control calibration eliminates the guess-work and the inaccuracy entailed in a visual estimate of an imaginary baseline which divides the waveform into equal areas and thus establishes the ratio of + to — peaks.

The design of a voltage calibrator operating along these lines may be approached in several ways. A simple variant of Fig. 4 will provide a limited range of baseline shift. The circuit is redrawn in Fig. 5 in which R_1 and R_2 have been replaced by potentiometer R_s capable of varying both clipping levels simultaneously with respect to the reference voltage V. If V is made equal to the peak value of E_s, the output at extreme settings of R_s will consist of half-wave rectified sine waves as indicated in Fig. 5. The maximum baseline shift obtainable when $V=E_s$=peak is 14% of the peak-to-peak excurison or a total of 28% as compared with a desirable maximum of 100%. Greater shifts are possible with extensions of this circuit, none of which have sufficient range or acceptable waveforms. The ideal waveshape of Fig. 2 (C and D) can best be approximated by an assymmetrical multivibrator. When the output pulse is taken from one of the plate loads of the multivibrator and the grid-to-cathode resistors are simultaneously varied in an opposite sense, pulse width changes over a range exceeding 95:1 can readily be obtained. However, while the positive leading edges are of acceptable steepness, the charging current of the coupling condenser through the plate load from which the output is taken gives the trailing edge of the negative pulse an exponential slope for low values of grid resistance. A low plate load will minimize this condition but a point is soon reached where oscillations cease or the output voltage falls below the required level. Inserting a direct-coupled cathode follower between the plate load and the condenser provides a low-impedance path for the condenser charging currents and improves the shape of the negative-going pulse considerably. The cathode follower is also a suitable driver for a pair of diode peak limiters of the type shown in Fig. 4 and Fig. 5. They will simultaneously square off the pulse tops and hold their maximum values to the limits determined by the bias.

A variable pulse width calibrator of this type is illustrated in Fig. 6. Use of a second cathode follower between the attenuator and the output of the calibrator permits high-impedance elements in the attenuator. Thus loading of the diodes becomes negligible and the wave tops are clipped perfectly. The low input capacity of the final cathode follower prevents degradation of the waveform at various attenuator settings. A pulse repetition rate of a few hundred cycles is satisfactory and aids in maintaining steep edges. Too low a frequency may result in flat top tilting due to falling off of the low-frequency response of the oscilloscope and thus sets the lower limit near one hundred cycles. The highly degenerative character of the final cathode follower maintains accuracy over wide ranges of load impedance and power line variations, the stage gain remaining fixed at 0.92. Use of two OB2 voltage regulator tubes limits the peak-to-peak amplitude at the output of the clipper to 206 volts, which is conveniently reduced to 200 volts by the cathode follower.

Baseline shift problems of a different nature are encountered with ordinary voltage calibrators when a direct-coupled oscilloscope is employed. Providing the calibrator output is axially symmetrical, the attenuator may be adjusted until the positive and negative peaks of the signal and calibrator coincide, depending on the polarity of the signal to be measured. Its peak-to-peak value is then one-half that indicated by the attenuator. This reduces the highest output range by the same ratio and limits the usefulness of the calibrator for the direct comparison method. The variable pulse width calibrator of Fig. 6 eliminates this difficulty by virtue of the coupling condenser at the output of the second cathode follower. At extreme settings of the baseline shift control, the a.c. axis of the pulse waveform approaches the zero d.c. level to within 2 per-cent of the peak-to-peak amplitude. Hence the output is practically unipolar and may, therefore, be directly compared with any d.c. signal having a peak amplitude of less than 200 volts. A central, horizontal grid line on the CRT screen extends the range to 400 volts without forfeiting the convenience and accuracy of the direct comparison method.

Fig. 6. Circuit of the calibrator. Attenuator range-switch S_1 is part of the push-button selector whose remaining functions have been omitted for simplicity.



The Auto-Sembly Technique

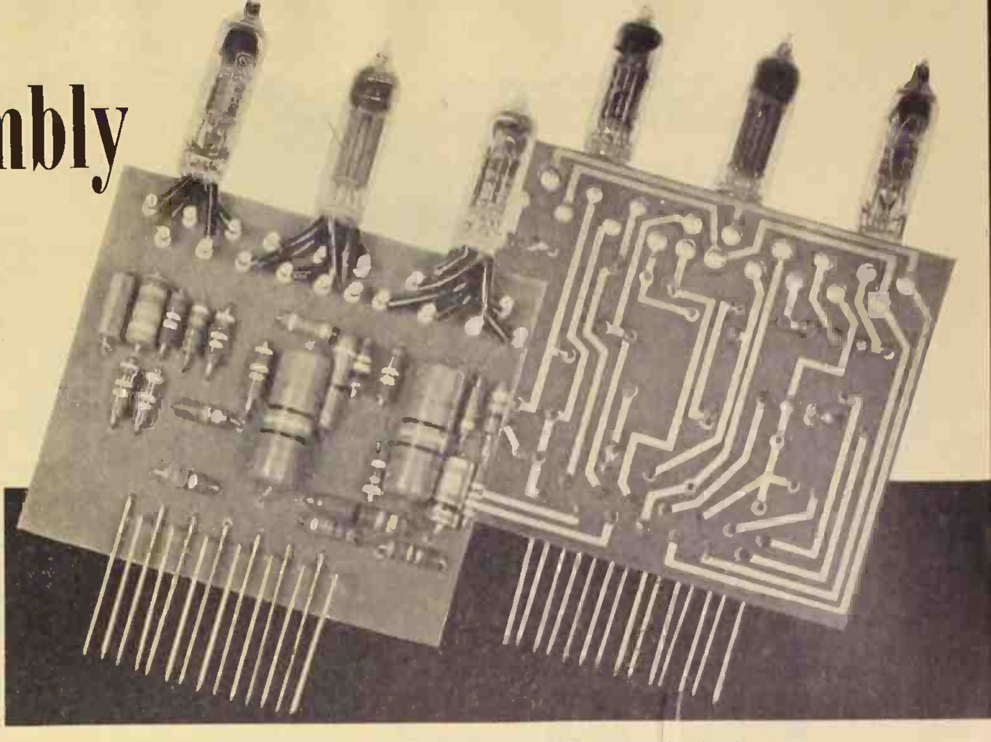


Fig. 1. Front (left) and back (right) views of typical electronic circuit built by Auto-Sembly techniques. The unit shown is an experimental model of a phase shift oscillator, amplitude limiter, and wave shaper.

An interesting, flexible, and realistic adaptation of printed circuitry to electronic circuit assembly.

THE Signal Corps Engineering Laboratories at Fort Monmouth, N. J., has developed a technique of miniature circuit fabrication called the Auto-Sembly process which promises to provide reductions in equipment size, mechanization of production to increase output and reduce error, and general manufacturing simplification in the construction of electronic products. The technique was described in a paper prepared by M. Abramson and S. Danko and presented by Mr. Abramson at the Radio Engineers Convention in New York on March 9, 1950.

The basic circuit of the device being built is first printed on a sheet of plastic, with holes at each point where a component termination is to be made. The components, which must have extended terminations, are then dropped in place with the leads passing through the appropriate holes. The plate is then dipped in solder, thus soldering the components to the printed circuit wiring. Excess lead lengths are snipped off and the unit is ready for processing.

Several techniques have been developed for fabrication of the conductive pattern. One method which appears to be meeting with considerable success consists of bonding a thin copper sheet to the plastic base by means of a suitable adhesive, then etching away the undesired portions in an acid bath. The pattern of the conductors is placed on the copper sheet before etching by a photographic process. The holes in the basic printed circuit can be easily formed by mass punching operations.

Components for mounting on this printed circuit base must have extended terminations such as lugs, wires, studs, etc. which will pass readily through the holes. Separately fabricated groups of components can also be adapted.

Loading these components onto the base may present some problems. At present, it appears that hand-loading is most suitable, but machines could certainly be built to make this loading operation completely automatic, if the quantity of finished units required were large enough to warrant the expense.

Several rapid soldering methods are adaptable. One technique consists of dipping the patterned surface in a flux and then momentarily in a molten solder bath, thus sweating the components to the pattern in one operation. This process does not have any adverse effect on the pattern or the surface of the plastic base.

The term "packaging" is used to indicate the preparation of a ruggedized and protected sub-assembly. Techniques of casting in thermosetting resins are well advanced, and offer an excellent approach to ruggedization.

Several features of the Auto-Sembly process appear to offer advantages in the mass production of electronic components, whether for military or civilian use. The costly process of hand-wiring and soldering, with the attendant possibility of errors, is eliminated. Accuracy and complete uniformity are assured, and rejects, other than those due to faulty components, practically eliminated.

The photographs show several units that have been laboratory fabricated by Signal Corps engineers to illustrate the versatility of the system.

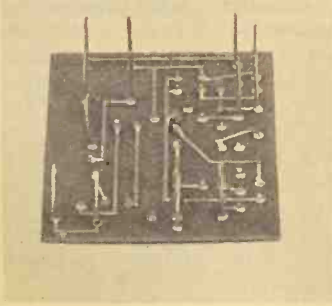


Fig. 2. Solder dipped pattern showing how the component terminations are solder joined to the pattern.

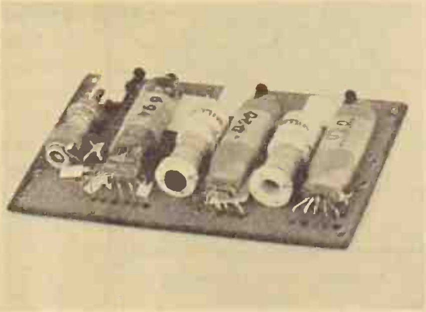


Fig. 3. A 50 megacycle radio-frequency amplifier and mixer that has been constructed using the Auto-Sembly process.

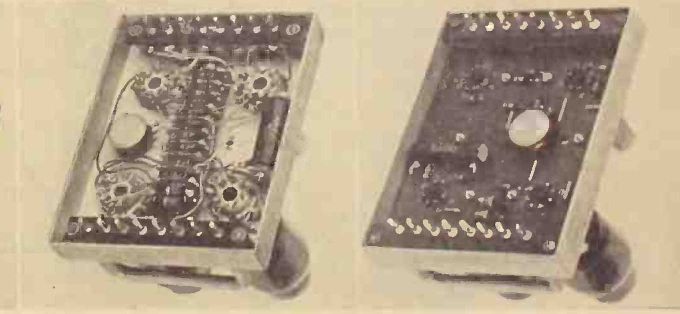
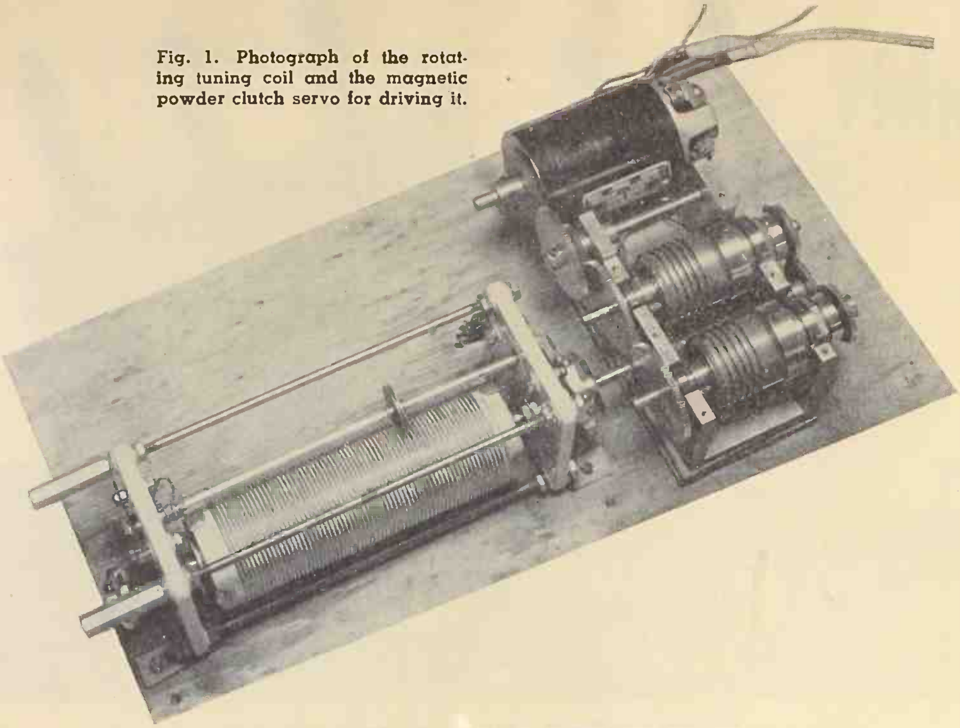


Fig. 4. (left) Underside of a conventionally built 20 watt d.c. amplifier compared to its exact Auto-Sembled counterpart (right). All wiring is on top-side of Auto-Sembled chassis.

Fig. 1. Photograph of the rotating tuning coil and the magnetic powder clutch servo for driving it.



MAGNETIC POWDER CLUTCH SERVO

By S. WALD, Principal Engineer
Bendix Radio Div., Bendix Aviation Corp.

Dry magnetic powder has some advantages over the so-called "magnetic fluid" in certain applications.

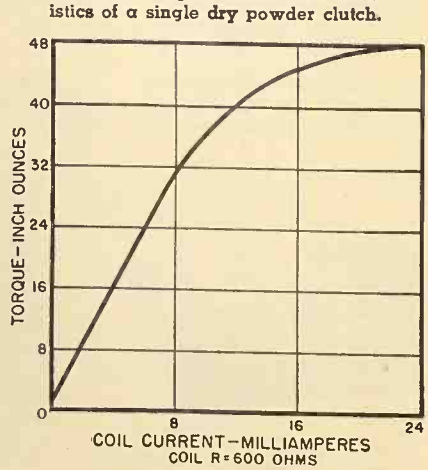
SINCE the announcement in April 1948 by the National Bureau of Standards that a mixture of powdered iron and oil could be used as a controllable friction medium in a clutch, there has been a justifiable widespread interest in both the phenomenon and its possible applications.

It was obvious that if some of the problems encountered in the use of the new "magnetic fluid" could be successfully overcome, a new and useful mechanism could be added to the repertoire of the electromechanical designer. There has always been the need for a clutch, which by means of a small control current, could interrupt or transmit large amounts of mechanical shaft power.

The fluid clutch promised to do this with an exceptionally smooth transition between these two extremes.

One important application for the clutch suggested itself almost immediately to the author, who was at the time of the disclosure of the principle engaged in the design of a high speed automatic tuning assembly for a military aircraft communications radio equipment.

Fig. 2. Torque-current characteristics of a single dry powder clutch.



The problem was to devise an electronically operated servo which could operate from a d.c. source (28 volts) and could accurately and rapidly position a multiturn inductance coil. Fig. 1 shows a picture of the rotating coil which has a diameter of two inches and is wound with about 60 turns of No. 16 bare silver wire. In order to accomplish the tuning in the allotted time a coil speed of 1200 r.p.m. would be necessary. Referring again to Fig. 1, the mechanical drive finally evolved consisted of two magnetically controlled clutches continuously driven in opposite directions by a d.c. motor. The driven element in each clutch is geared to a common output shaft. Thus, if clutch number one is energized, the coil will be driven in one direction. If number two is energized, the coil is driven in the opposite direction. The two clutches are not energized simultaneously. The purpose of this article is to discuss some of the shortcomings of the magnetic fluid filled clutch and how the development of a dry powder unit resulted in a successful design for this application. Fnally, the circuit of the drive system will be covered briefly.

As an initial step in the development, a magnetic fluid clutch was designed around the following requirements:

1. Clutch speed—1000 to 2000 r.p.m.
2. Torque—48 inch ounces
3. Ambient temperature range −55°C. to +85°C.
4. Size and weight to be a minimum

The first design was a failure from the standpoint of a practical device but was valuable in pointing out the difficulties that had to be surmounted in subsequent designs. In the first place the viscous drag of the magnetic fluid with zero excitation was about 16 inch ounces at 1200 r.p.m., while the maximum torque which could be transmitted without slippage was about 40 inch ounces. The magnetic fluid was a nine to one mixture by weight of Carbonyl "E" powdered iron and *Dow-Corning* DC-200, 10 c.s.k. viscosity silicone.

Besides having high viscous drag, the iron powder in the mixture settled out and increased the drag still further. In order to forestall settling out of the powder, a wetting agent was added to the mixture very early in the development. A number of different additives, such as Butyl oleate and Antarox B-100, were suggested by both the Bureau of Standards and *General Aniline and Film Company*, Antara Division. However, the extreme heating caused by viscous drag resulted in breakdown of the additive and again the powder in the mixture would cake and settle out.

After many unsuccessful attempts to operate a magnetic fluid clutch at high rotational speeds, it was decided to attempt a somewhat unorthodox approach to the problem, that is, elimination of the fluid medium and to use only the powdered iron. The author was aware that although the liquid in the mixture imparted many desirable characteristics to the operation of the clutch, such as smooth engagement, good heat transfer and protected the iron powder from rapid oxidation, most of the difficulties at high speeds were attributable directly to it. Accordingly, it was decided to design a clutch to use Carbonyl "E" iron powder in the dry state. Fig. 5 shows the main sub-assemblies and an assembled dry powder magnetic clutch which performed successfully at speeds up to 5000 r.p.m.

The exciting coil and housing rotate as a unit and cause a radial magnetic flux in the air gap of the hat-shaped sub-assembly shown in the lower center of Fig. 5. The portion shown at the extreme right comprises a cup-shaped rotor with a number of axial slots, a double bearing and a simple shaft seal. The complete clutch assembly appears in the upper portion of Fig. 5. Here the housing, which is one clutch member, is rigidly attached to the large gear at the right and supported by a large diameter ball bearing at the left and the small bearing at the right. The second clutch member terminates in the smaller spur gear at the left end. About two grams of Carbonyl "E" are placed in the air gap sub-assembly prior to joining the two main portions of the device by means of the coupling nut. Fig. 3 shows a cross section of an improved version of the clutch shown in Fig. 5.

It can be seen that the air-gap sub-assembly in Fig. 3 is no longer hat-shaped but flush on both sides to give better mechanical alignment and to reduce the magnetic reluctance. The coil has 3700 turns of No. 38 Formex wire and a resistance of 600 ohms. Depth of the cup-shaped rotor element is approximately ¼ inch, while the radial gap is .012 inch. The diameter of the cup is 1 inch and about 5 grams of Carbonyl "E" powder is required for proper operation. The quantity of powder is not critical provided an excess is avoided.

Tests of the clutch model shown in Fig. 5 showed the design to be quite practical. At 2000 r.p.m. there was negligible drag due to the iron powder. Fig. 2 shows the torque vs. current characteristic. Frictional drag including seal was constant at about 2-3 inch ounces, independent of speed. All low temperature limitations are removed, the clutch being operative down to the lowest temperature tried—that of "dry" ice. There is no loss of torque if the maximum iron powder temperature is restricted to about 150°C.

Since there is no mixture, there are no separation problems associated with centrifuging. Shaft seals become a minor problem because of the absence of the fluid and simple devices such as the National or Perfect oil seal or Chicago Rawhide "sirvene" seal have a life depending only on shaft hardness, runout, and finish. Problems of expansion, internal pressure, and loss of

(*Continued on page* 26A)

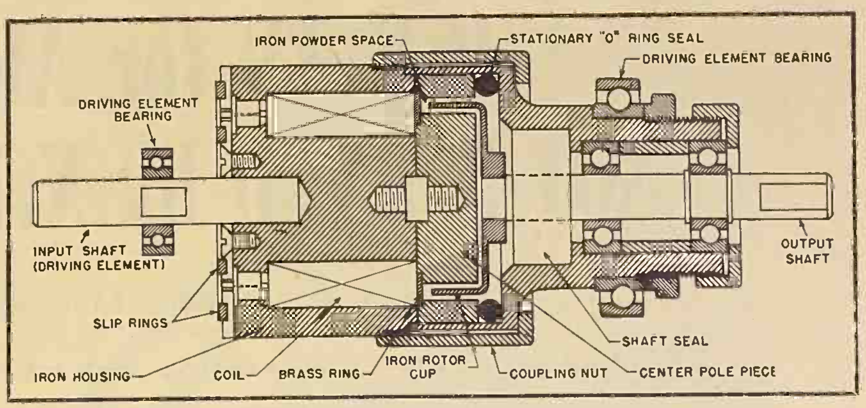


Fig. 3. Sketch showing the final design of the magnetic powder clutch unit.

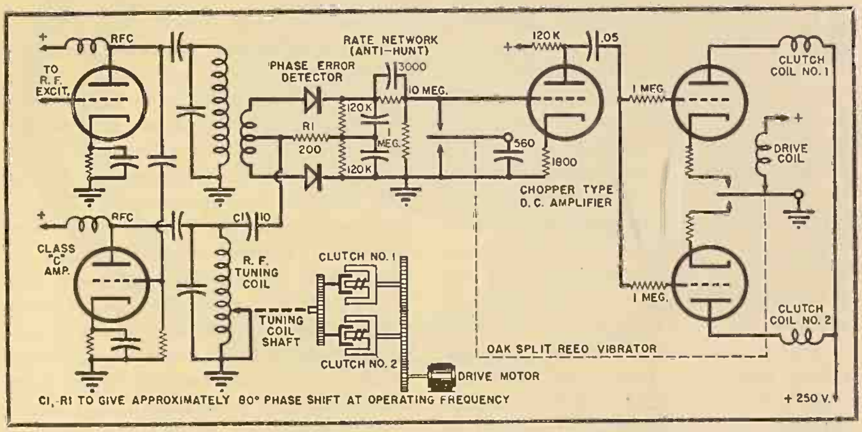
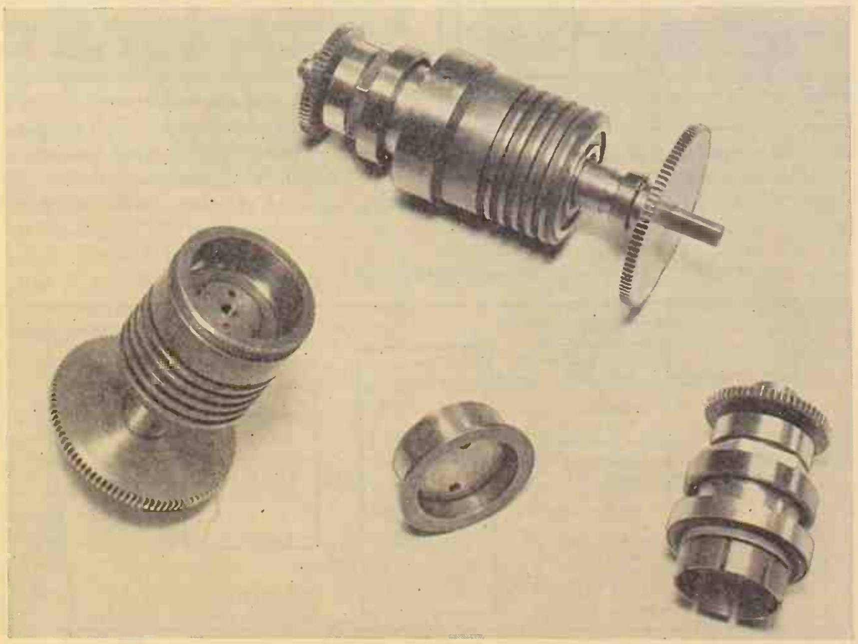


Fig. 4. Magnetic powder clutch servo drive as applied to transmitter automatic tuning.

Fig. 5. Complete clutch assembly (top), with component parts shown below.



U.H.F. TV for AREAS NOT SERVED by V.H.F. TV

By J. R. POPKIN-CLURMAN
Hazeltine Electronics Corp.

Modulating a u.h.f. transmitter with v.h.f. TV channels will permit the use of conventional v.h.f. TV receivers.

ONE of the knotty problems presently facing the television industry and the Federal Communications Commission is that of u.h.f. television. The public is also concerned because a u.h.f. television receiver is necessarily more expensive than a conventional TV set, as it must accommodate the standard channels and have additional circuitry for the u.h.f. channels. Further, the u.h.f. television receiver is more costly to produce than a straight v.h.f. set due to the difficulties of adjustment, alignment and holding within production tolerances. Also the small volume of u.h.f. sets that would initially be manufactured will result in an increase in the unit cost.

These added costs of u.h.f. receivers will minimize their use in areas now served by v.h.f. television stations, and a new u.h.f. broadcaster in these sections would have a hard time establishing profitable operations in the face of the existing audiences for v.h.f. For this reason, u.h.f. television is likely to be confined largely to those areas not now served by v.h.f. stations.

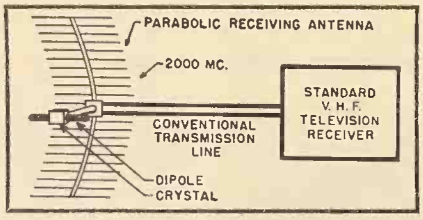


Fig. 1. The u.h.f. signal is detected at the antenna and conventional v.h.f. signals pass to the receiver.

Recent surveys indicate that few of the major marketing areas still remain to be developed for television broadcasting. For these areas not yet having TV service the potential television audience is limited and does not economically justify more than one or two u.h.f. stations, unless some new economical way could be found to provide multi-program service. For the many medium-sized cities in this class there is a definite need for some practical means of providing a real choice of TV programs, such as a selection of four to seven different available transmissions.

With the above considerations in mind the system described in this article is proposed. It is a method affording economical u.h.f. television. The system envisages each viewer using an ordinary v.h.f. television receiver with absolutely no alterations, the only new feature being an inexpensive special antenna embodying a crystal detector. The television signals would be received at 700, 2000, or 3000 mc., or any other suitable point in the u.h.f. band. The key to the success of the proposed system lies in the crystal mixer-detector, which is part of a small high-gain receiving antenna. Because of the use of v.h.f. amplitude modulation for the transmission of the u.h.f. television signals, the crystal at the antenna detects this modulation on the u.h.f. carrier and thus delivers complete TV signals for the usual v.h.f. television channels, such as Channel 2, 3, 4, etc. See Fig. 1. These channels are radiated as modulation sidebands separated from the u.h.f. carrier by the amount of the sound and picture carriers and associated frequencies, such as 54 to 60 mc. for Channel 2. The receiving antenna has connected to it a conventional 300-ohm transmission line or other v.h.f. connecting cable, down which the demodulated v.h.f. signals pass from the crystal detector to the conventional television receiver. The losses in the transmission line are only those existing for the normal v.h.f. region of the spectrum. As far as the public is concerned, they tune the television receiver exactly the same way as for standard television broadcasts, and the viewer may not know that special frequencies and additional modulation are being utilized to deliver programs to him.

Fig. 2. Block diagram showing how signal is produced at transmitter.

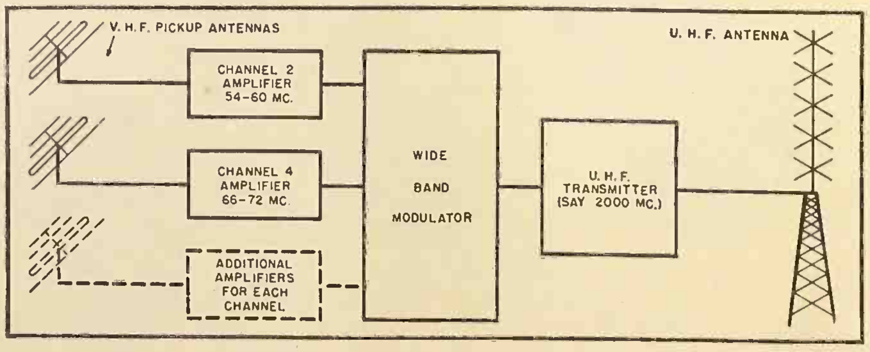
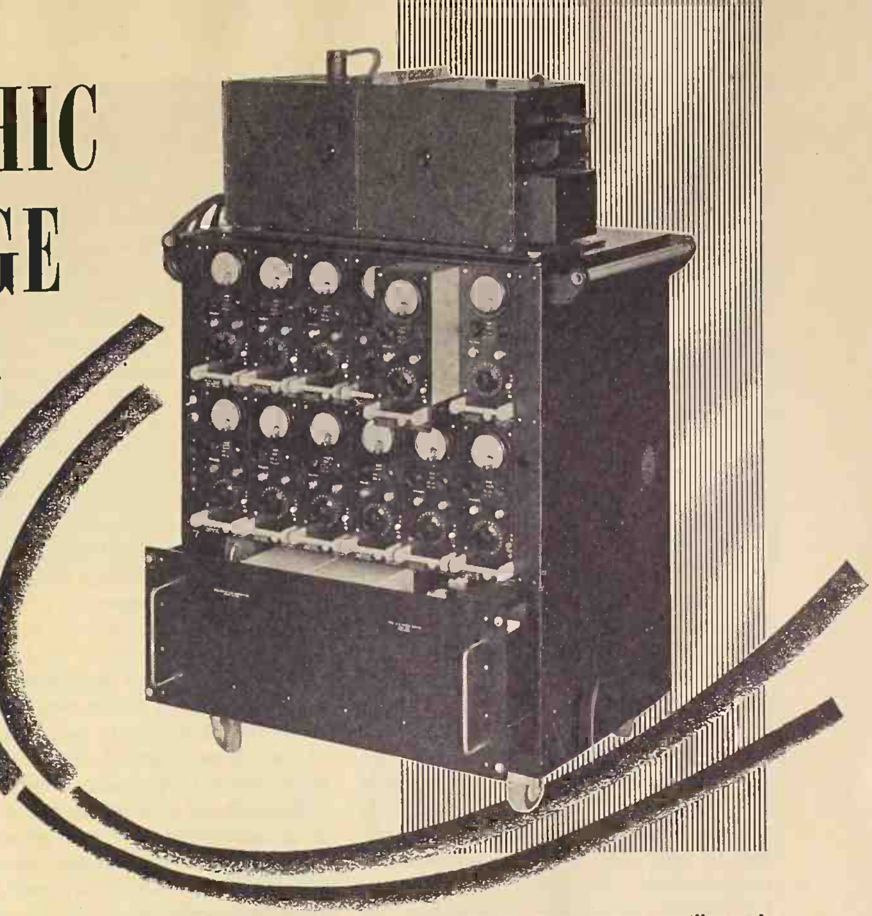


Fig. 2 shows how this type of signal is produced at the transmitter. Signals are first generated at v.h.f. channel frequencies and are complete with sync, blanking, video, and sound. These are obtainable in a number of ways. For example, signals picked up from v.h.f. stations outside of the normal area to be covered by the u.h.f. transmitter may be directly received by a well located antenna and low-noise receiver and reamplified, all at v.h.f. Or such signals from v.h.f. stations at fair distances may be brought in over a special TV relay system of one or two radio repeaters. As an alternative, the video may be derived locally from camera chains, etc., or be tapped off coaxial cable or obtained from existing microwave television relay systems.

An important feature is that in case there is some interference with an existing v.h.f. signal in a u.h.f. area, the v.h.f program may be remodulated before being fed into the u.h.f. transmitter so as to occupy an unused v.h.f. channel. (*Continued on page* 29A)

OSCILLOGRAPHIC STRAIN GAUGE RECORDING



Model H recording oscillograph arranged for use with amplifier.

By ALVIN B. KAUFMAN

Factors such as galvanometer damping and resonant frequency must be considered.

THE recording of stress or strain, as indicated by strain gauge output voltage, may be done with a simple *L & N* potentiometer, galvanometer, or complex automatic potentiometer where static or quasi-static testing is performed. However, where several or more strains are to be recorded along with other associated phenomena, or where *dynamic* data is to be recorded, it is no longer possible to coordinate meter readings or to read high meter fluctuations visually, even were the meters to respond.

Oscillographs to record dynamic and multi-channel information are therefore used commonly in the recording of strain gauge data. These oscillographs may be grouped roughly into three types, only one of which is used to a large extent. The recording medium: film, photosensitive paper, or paper (plain, wax, or heat resistive) determines the group type of oscillograph and indirectly its usability for dynamic recording.

Film recorders are normally used for very high speed transient phenomena and employ cathode ray tubes for the "writing" mechanism. They are very good, but limited in use, generally being both bulky and heavy and having not over one to six recording channels. The recording frequency response is almost unlimited.

Paper recorders consist almost always of a D'Arsonval meter movement of one type or another operating a pointer carrying either an inking mechanism (*Esterline-Angus*), a scratching or marking device (*Brush*), or a hot element (*Sanborn*). This class of recorder is suitable only for very low dynamic frequencies and suffers generally for lack of recording channels, excessive weight, and a sensitiveness to vibration. They can be very excellent for the recording of static and very low frequency dynamic information, any test recording being instantly available for examination without development time.

The photosensitive paper recorder is by far the most popular oscillograph with electrical engineers, due to its light weight, many recording channels (6 to 48), high frequency response, and easily changed galvanometers. The galvanometers are of the moving coil type (Fig. 3) in which a folded wire lies in a magnetic field. A small mirror is cemented to the wires and as the wires turn in the field (with application of current) the mirror reflects a spot of light on a moving roll of photosensitive paper (or film). After any records are run, a magazine containing the exposed paper is removed from the oscillograph and developed in a dark room with the usual photographic techniques. As this phase of oscillographic recording is covered adequately by the manufacturers of the recording papers, there is no need for this article to elaborate and only the electronic phase of oscillograph recording will be discussed.

The recording of oscillograph records is basically simple in theory but complex in practice where accurate records are desired. That there is considerable variation in recording systems may be suggested by a breakdown of the components used. These components are the strain gauge bridge circuit, amplification system (if any), and the type and characteristics of the recording galvanometer. Each of these items is much more complex than is at first apparent.

The recording galvanometers used in modern oscillographs are almost always of the moving coil design suspended in silicone or other damping oils. Crystal and other forms of recording heads have been made but they are not commonly in commercial use today. The action of the moving coil galvanometer is essentially that of a simple direct current motor, except the field is a permanent magnet and the armature consists of the reflecting mirror across which the two or more armature wires are cemented. Here any similarity ceases and problems of critical damping, natural resonant frequency, etc., must be resolved to make the galvanometer useful.

A galvanometer's natural frequency and its damping determine its utility. This natural frequency (or resonance) should be two or more times higher than the fundamental frequency to be recorded. When it is desirable to record the normal harmonics of the fundamental without excessive distortion, then the galvanometer natural frequency should be five times or higher than the fundamental. In practice, this strict a requirement is not necessary unless the harmonic content is sufficiently high

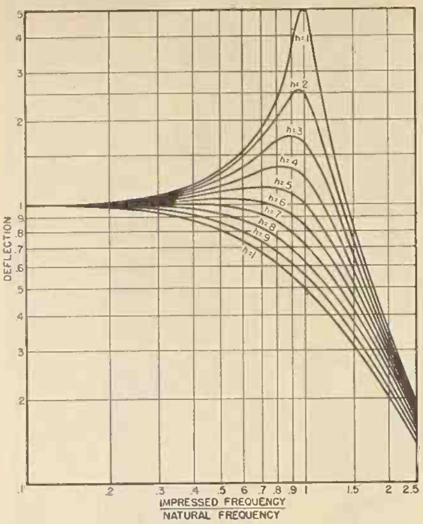


Fig. 1. Galvanometer response for various degrees of damping.

to warrant investigation. The frequency at which this type of galvanometer is resonant depends to some extent upon the mass of the moving elements and the tightness to which the wire armature is stretched. This tightness and the extent of the galvanometer integral damping is regulated by the galvanometer manufacturer. The galvanometer damping depends to a great extent upon the fluid encompassing the moving element and the external shunting resistance of the bridge or circuit. Therefore, matching impedances for maximum sensitivity may not result in the best value of damping. Too high or too low will reduce the constant frequency response to less than 50% of its natural frequency, which is generally considered attainable with critical damping of the order of .6 to .7. The effect of various degrees of damping is shown clearly by the curves in Fig. 1. The degree of damping will also vary with temperature, where liquid damping is used, unless silicone or other oil of constant viscosity is employed as the damping medium.

For aircraft testing a range of recording frequencies from 0 to 30 c.p.s is quite satisfactory for general aerodynamic information. With engine speeds of 1800 r.p.m., fundamental vibration frequencies of 30 c.p.s. may be generated mechanically, whereas flutter frequencies are generally much lower. As damping may vary, a galvanometer of 75 cycle (or higher) resonance would be the best choice for general aircraft flight test use. As the sensitivity or deflection of a galvanometer is inversely proportional to the square of its natural frequency it is unadvisable to use a galvanometer whose natural resonant frequency is any higher than absolutely required. As an example, a *Wm. Miller Corporation* galvanometer with a natural frequency range of 30 c.p.s. has a sensitivity of *five microamperes* per inch deflection at the record (or paper), a similar 3500 c.p.s. galvanometer in the same oscillograph requires *65 milliamperes* for the same deflection.

Regardless of how the galvanometer is matched to the bridge or output of the amplifier, a definite relationship should be maintained between the galvanometer resistance and the generator impedance if optimum sensitivity is to be achieved. As indicated previously, this condition may lead to a loss of constant frequency response, as the galvanometer damping varies from critical. If this change of damping does not pull the galvanometer constant response below the region of the frequencies to be recorded then the optimum configuration exists. Otherwise it would be necessary to deliberately mismatch the galvanometer or change to another one with a higher natural frequency to obtain the required recording frequency range. It is then necessary to estimate or calculate which method of securing the desired frequency range would cause the least loss in sensitivity. If amplification is employed, the output impedance can be adjusted to the value for optimum damping and the amplifier gain increased to handle the loss due to mismatch. Where the galvanometer is to be operated directly from a strain gauge bridge, maximum sensitivity may be required to secure a satisfactory record and this problem is more acute. The mathematical formulas for optimum matching will be discussed later.

As the damping of a given galvanometer may vary due to internal factors or external impedance matching, it is important to determine the constant frequency range of the galvanometer with the operating configuration used at recording time. The degree of damping may be determined roughly by the "decay" method, but possibly more practically by a constant signal level calibration. Fig. 2 shows a typical set of decay curves of a galvanometer which has been deflected to a uniform amount and then allowed to seek its natural repose. The degree of usable constant frequency response may be determined by supplying the galvanometer with a steady voltage of variable frequency and then plotting the deflection amplitude against frequency. It will also be possible to determine the galvanometer's natural frequency (unshunted) by increasing the frequency of the supply and determining what frequency causes maximum amplitude. Knowing the natural frequency, the external shunting (or output impedance) for critical damping may be determined by adjusting the impedance until the galvanometer response is flat to 50% of the natural frequency.

The galvanometer may be operated by other equipment than strain gauges. A typical use is shown in the photograph of a recording made on an electrical spot welding machine. Here a strain gauge recording of electrode pressures is accompanied by voltage, current, and operation of associated relays as indicated. As this record had no timing traces across the paper, the 60 cycle sine wave at one side of the record was recorded to be used for time measurement.

The combination of these factors on one record allowed the sequences of operation to be noted, an invaluable use in many industrial processes. In aircraft, position, pressures, loads, and other phenomena are commonly recorded together to give an over-all picture of flight conditions. There may be a combination of photographic and oscillographic recording, as the occasion demands. With the aid of a transducer any phenomenon may be recorded.

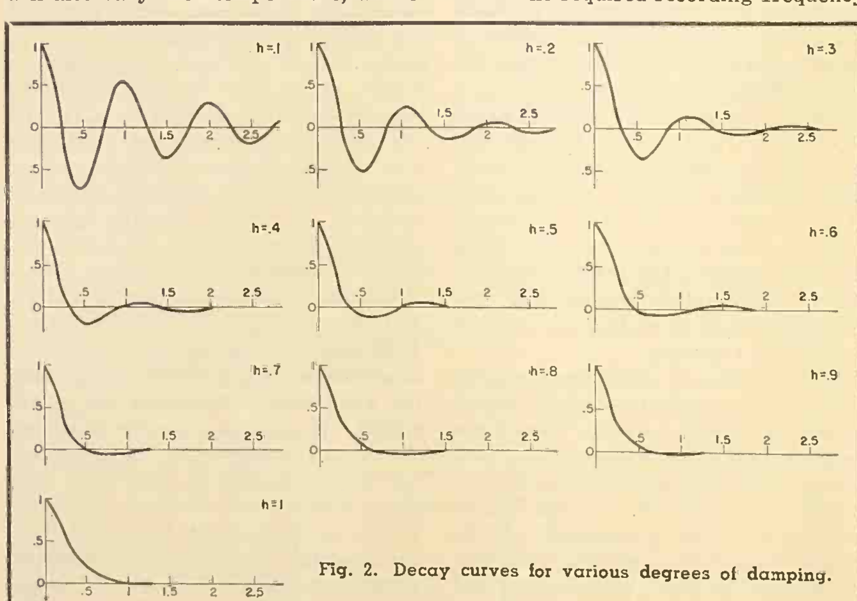


Fig. 2. Decay curves for various degrees of damping.

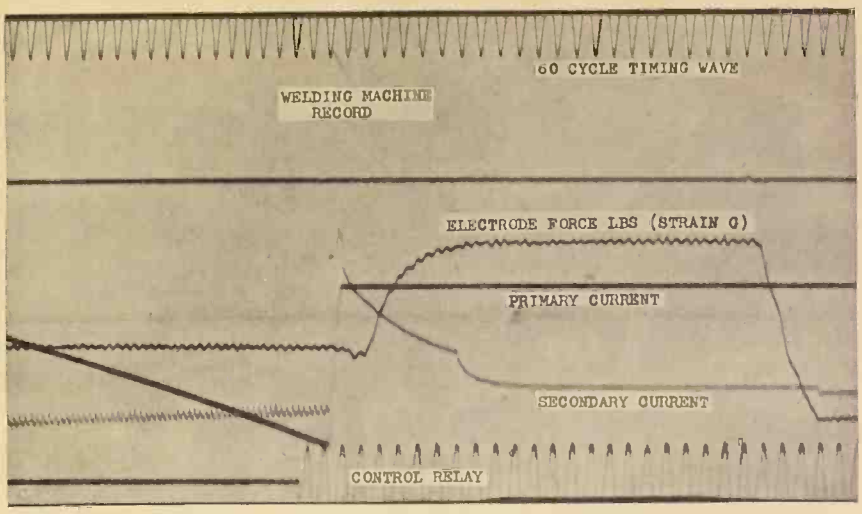
Typical recording oscillograph used in the aircraft field is the *Wm. Miller Corporation,* Model H unit. It records on a six inch wide record strip, 200 feet long, and is usually constructed with twelve galvanometer channels having isolated return circuits. As many as seventeen channels can be built into this model instrument. Provision is made for visual scanning of the galvanometer traces simultaneously with or without recording, and for cutting and perforating the individual records. A record number is automatically photographed on each record. The timing system is tuning fork controlled and photographs timing lines across the record each .01 second. The oscillograph can be constructed with record speeds from a fraction of an inch per second to more than 48" per second. The commonest speed ranges supplied are either 4" to 24" per second, or 8" to 48" per second, each with two intermediate speeds. The *Hathaway Instrument Company* manufactures an oscillograph with a regular gear box allowing a much wider range of recording speed, but at the sacrifice of weight. There are many companies manufacturing oscillographs, of many types. This article will not attempt to describe them, but will endeavor to indicate recording systems and circuits.

A large number of methods have been used to apply the strain gauge signal to the recording galvanometer. The galvanometer has been connected directly into a variety of d.c. bridge circuits, or into the output of an amplifier system.

Strain gauge amplifier systems, in general use, are of three types. These are the d.c. amplifier or the a.c. bridge carrier systems employing either amplitude or phase sensitive detection. The direct-coupled amplifier is used with direct voltage on the bridge. The amplifier must necessarily be a direct-coupled or d.c. amplifier if steady components of the strain are to be recorded. This type of amplifier is subject to drift (i.e., change in output indication with no change in input signal) and usually is not stable unless unduly complicated. This error can be minimized if the "zero" is frequently checked manually or automatically by special circuit design. As indicated, where long term stability is required this amplification system is unsatisfactory.

With a.c. power supplied to the strain gauge bridge, any unbalance bridge voltage may be amplified and detected back into d.c. variations. The name "carrier system" comes from the analogy to the amplitude modulated carrier in ordinary radio broadcasting. The frequency of the output voltage, called the carrier frequency, is the same as the frequency of the bridge supply voltage. The carrier frequency, as with broadcasting, must be 10 to 15 times higher in frequency than the intelligence it is to carry. The higher the carrier frequency the easier it is to filter out the hash components of the carrier from the d.c. output signal. The polarity of the rectified signal will not change regardless of which way the bridge is unbalanced from null. For this reason the bridge is generally balanced off of the null position so that any resulting change in strain upward or downward can be indicated. An ambiguity is sometimes produced when the strain causes a down scale deflection *through* the null point.

A bridge may be perfectly balanced for direct current but show a considerable output when a 1000 cycle signal is used for the bridge energizing source. This is due to unbalanced capacitances from stray wire, etc., that exist across the arms of the bridge. An a.c. bridge must be balanced capacitively as well as resistively. The difficulty is overcome by including a reactance control in the balancing system, consisting of adjustable shunt capacities. In practice then, the bridge is brought to balance (or null) for zero load by means of both



Recording made on an electrical spot welding machine.

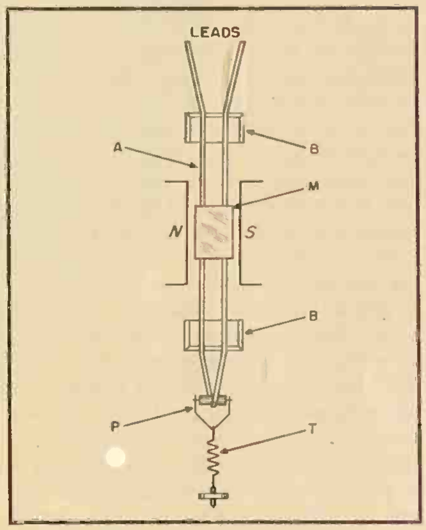
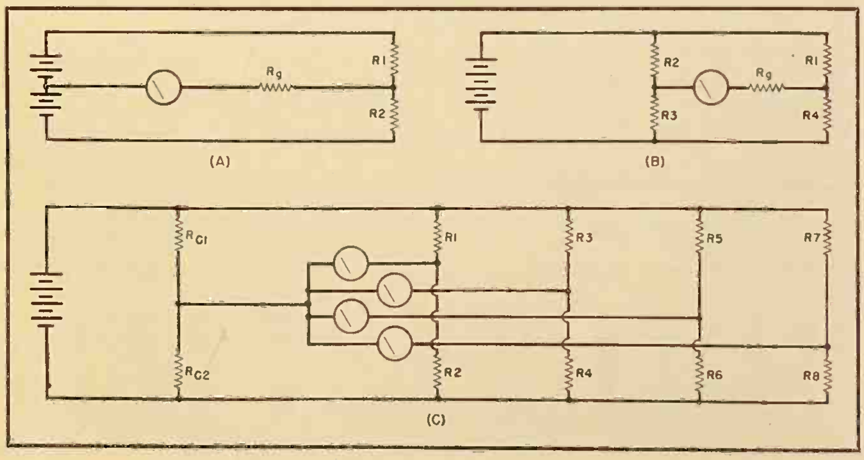


Fig. 3. Typical basic galvanometer unit. A—armature wire; B—ivory bridges; P—pulley; T—tension spring; M—mirror.

Fig. 4. Simplified bridge circuits. (A) Battery bridge. (B) Wheatstone bridge. (C) Wheatstone bridge incorporating low value fixed resistance as two bridge arms, simulating carrier type of configuration.



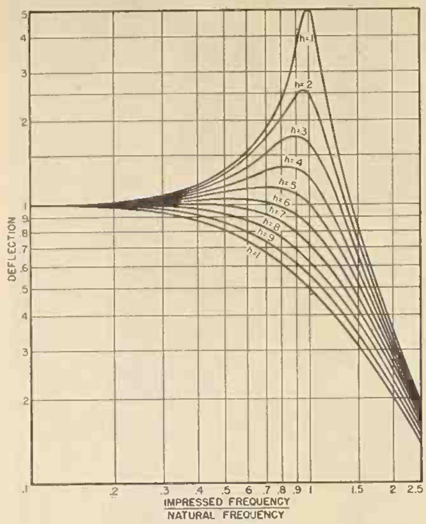


Fig. 1. Galvanometer response for various degrees of damping.

to warrant investigation. The frequency at which this type of galvanometer is resonant depends to some extent upon the mass of the moving elements and the tightness to which the wire armature is stretched. This tightness and the extent of the galvanometer integral damping is regulated by the galvanometer manufacturer. The galvanometer damping depends to a great extent upon the fluid encompassing the moving element and the external shunting resistance of the bridge or circuit. Therefore, matching impedances for maximum sensitivity may not result in the best value of damping. Too high or too low will reduce the constant frequency response to less than 50% of its natural frequency, which is generally considered attainable with critical damping of the order of .6 to .7. The effect of various degrees of damping is shown clearly by the curves in Fig. 1. The degree of damping will also vary with temperature, where liquid damping is used, unless silicone or other oil of constant viscosity is employed as the damping medium.

For aircraft testing a range of recording frequencies from 0 to 30 c.p.s is quite satisfactory for general aerodynamic information. With engine speeds of 1800 r.p.m., fundamental vibration frequencies of 30 c.p.s. may be generated mechanically, whereas flutter frequencies are generally much lower. As damping may vary, a galvanometer of 75 cycle (or higher) resonance would be the best choice for general aircraft flight test use. As the sensitivity or deflection of a galvanometer is inversely proportional to the square of its natural frequency it is unadvisable to use a galvanometer whose natural resonant frequency is any higher than absolutely required. As an example, a *Wm. Miller Corporation* galvanometer with a natural frequency range of 30 c.p.s. has a sensitivity of *five microamperes* per inch deflection at the record (or paper), a similar 3500 c.p.s. galvanometer in the same oscillograph requires *65 milliamperes* for the same deflection.

Regardless of how the galvanometer is matched to the bridge or output of the amplifier, a definite relationship should be maintained between the galvanometer resistance and the generator impedance if optimum sensitivity is to be achieved. As indicated previously, this condition may lead to a loss of constant frequency response, as the galvanometer damping varies from critical. If this change of damping does not pull the galvanometer constant response below the region of the frequencies to be recorded then the optimum configuration exists. Otherwise it would be necessary to deliberately mismatch the galvanometer or change to another one with a higher natural frequency to obtain the required recording frequency range. It is then necessary to estimate or calculate which method of securing the desired frequency range would cause the least loss in sensitivity. If amplification is employed, the output impedance can be adjusted to the value for optimum damping and the amplifier gain increased to handle the loss due to mismatch. Where the galvanometer is to be operated directly from a strain gauge bridge, maximum sensitivity may be required to secure a satisfactory record and this problem is more acute. The mathematical formulas for optimum matching will be discussed later.

As the damping of a given galvanometer may vary due to internal factors or external impedance matching, it is important to determine the constant frequency range of the galvanometer with the operating configuration used at recording time. The degree of damping may be determined roughly by the "decay" method, but possibly more practically by a constant signal level calibration. Fig. 2 shows a typical set of decay curves of a galvanometer which has been deflected to a uniform amount and then allowed to seek its natural repose. The degree of usable constant frequency response may be determined by supplying the galvanometer with a steady voltage of variable frequency and then plotting the deflection amplitude against frequency. It will also be possible to determine the galvanometer's natural frequency (unshunted) by increasing the frequency of the supply and determining what frequency causes maximum amplitude. Knowing the natural frequency, the external shunting (or output impedance) for critical damping may be determined by adjusting the impedance until the galvanometer response is flat to 50% of the natural frequency.

The galvanometer may be operated by other equipment than strain gauges. A typical use is shown in the photograph of a recording made on an electrical spot welding machine. Here a strain gauge recording of electrode pressures is accompanied by voltage, current, and operation of associated relays as indicated. As this record had no timing traces across the paper, the 60 cycle sine wave at one side of the record was recorded to be used for time measurement.

The combination of these factors on one record allowed the sequences of operation to be noted, an invaluable use in many industrial processes. In aircraft, position, pressures, loads, and other phenomena are commonly recorded together to give an over-all picture of flight conditions. There may be a combination of photographic and oscillographic recording, as the occasion demands. With the aid of a transducer any phenomenon may be recorded.

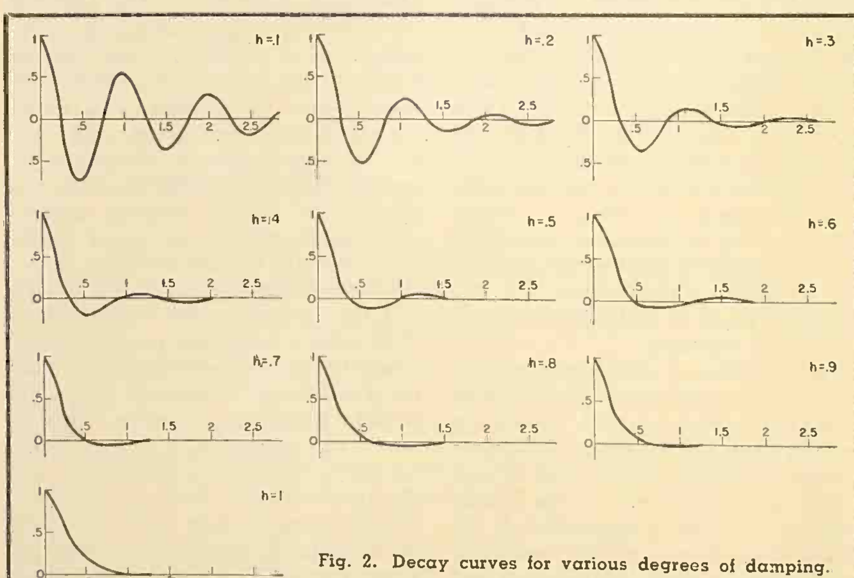


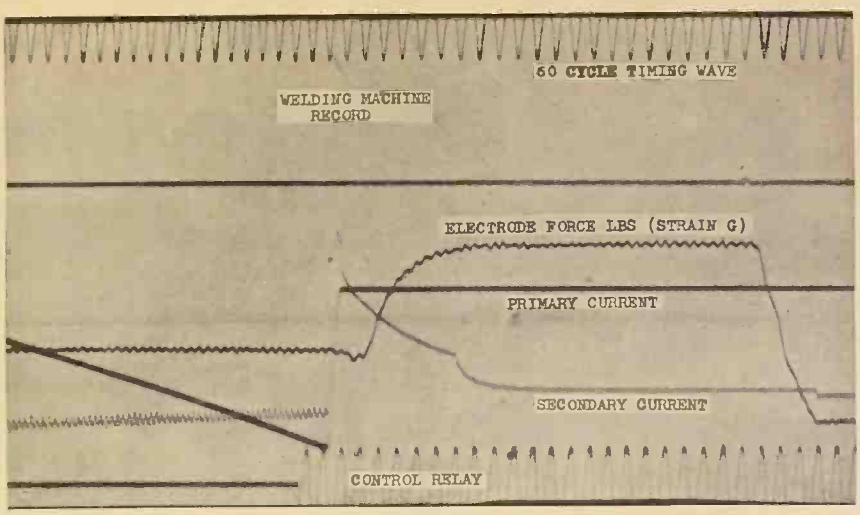
Fig. 2. Decay curves for various degrees of damping.

Typical recording oscillograph used in the aircraft field is the *Wm. Miller Corporation*, Model H unit. It records on a six inch wide record strip, 200 feet long, and is usually constructed with twelve galvanometer channels having isolated return circuits. As many as seventeen channels can be built into this model instrument. Provision is made for visual scanning of the galvanometer traces simultaneously with or without recording, and for cutting and perforating the individual records. A record number is automatically photographed on each record. The timing system is tuning fork controlled and photographs timing lines across the record each .01 second. The oscillograph can be constructed with record speeds from a fraction of an inch per second to more than 48" per second. The commonest speed ranges supplied are either 4" to 24" per second, or 8" to 48" per second, each with two intermediate speeds. The *Hathaway Instrument Company* manufactures an oscillograph with a regular gear box allowing a much wider range of recording speed, but at the sacrifice of weight. There are many companies manufacturing oscillographs, of many types. This article will not attempt to describe them, but will endeavor to indicate recording systems and circuits.

A large number of methods have been used to apply the strain gauge signal to the recording galvanometer. The galvanometer has been connected directly into a variety of d.c. bridge circuits, or into the output of an amplifier system.

Strain gauge amplifier systems, in general use, are of three types. These are the d.c. amplifier or the a.c. bridge carrier systems employing either amplitude or phase sensitive detection. The direct-coupled amplifier is used with direct voltage on the bridge. The amplifier must necessarily be a direct-coupled or d.c. amplifier if steady components of the strain are to be recorded. This type of amplifier is subject to drift (i.e., change in output indication with no change in input signal) and usually is not stable unless unduly complicated. This error can be minimized if the "zero" is frequently checked manually or automatically by special circuit design. As indicated, where long term stability is required this amplification system is unsatisfactory.

With a.c. power supplied to the strain gauge bridge, any unbalance bridge voltage may be amplified and detected back into d.c. variations. The name "carrier system" comes from the analogy to the amplitude modulated carrier in ordinary radio broadcasting. The frequency of the output voltage, called the carrier frequency, is the same as the frequency of the bridge supply voltage. The carrier frequency, as with



Recording made on an electrical spot welding machine.

broadcasting, must be 10 to 15 times higher in frequency than the intelligence it is to carry. The higher the carrier frequency the easier it is to filter out the hash components of the carrier from the d.c. output signal. The polarity of the rectified signal will not change regardless of which way the bridge is unbalanced from null. For this reason the bridge is generally balanced off of the null position so that any resulting change in strain upward or downward can be indicated. An ambiguity is sometimes produced when the strain causes a down scale deflection *through* the null point.

A bridge may be perfectly balanced for direct current but show a considerable output when a 1000 cycle signal is used for the bridge energizing source. This is due to unbalanced capacitances from stray wire, etc., that exist across the arms of the bridge. An a.c. bridge must be balanced capacitively as well as resistively. The difficulty is overcome by including a reactance control in the balancing system, consisting of adjustable shunt capacities. In practice then, the bridge is brought to balance (or null) for zero load by means of both

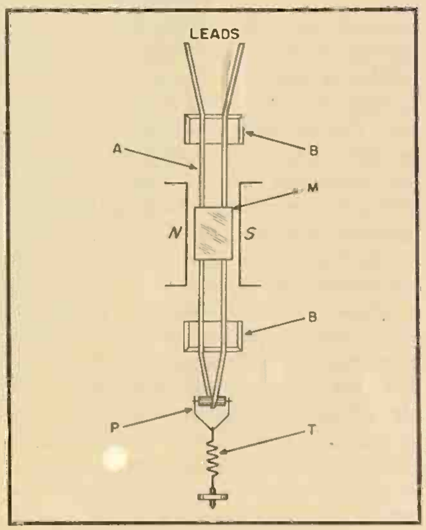
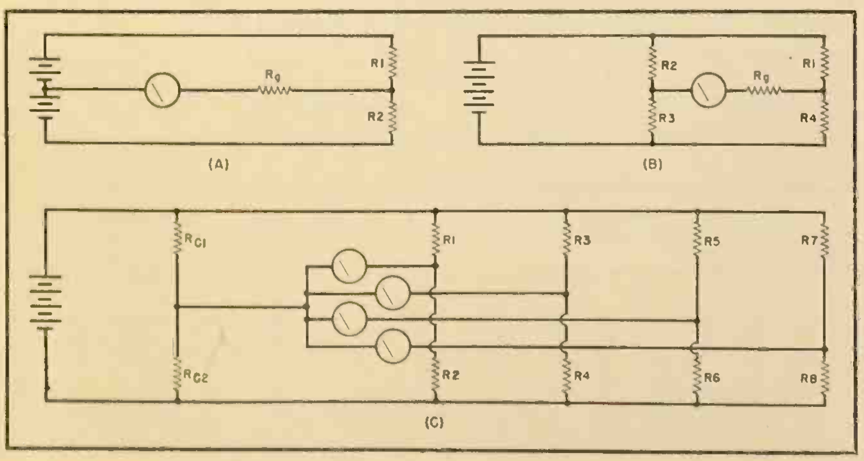
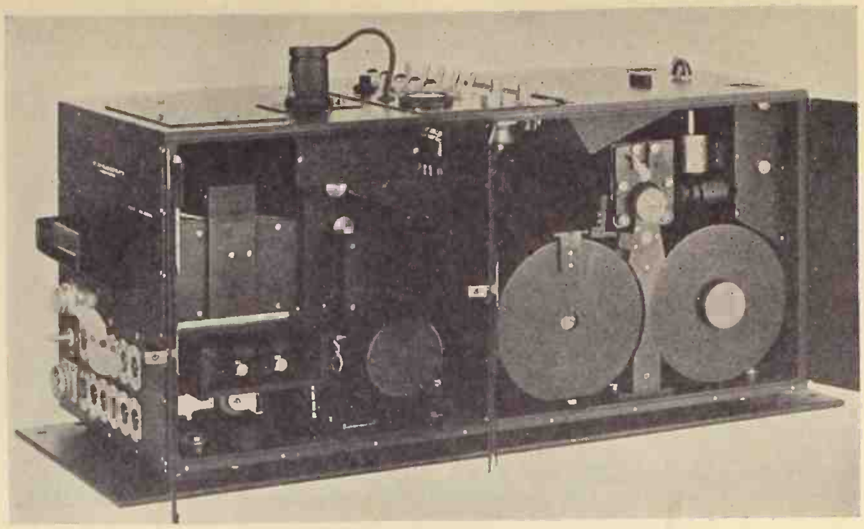


Fig. 3. Typical basic galvanometer unit. A—armature wire; B—ivory bridges; P—pulley; T—tension spring; M—mirror.

Fig. 4. Simplified bridge circuits. (A) Battery bridge. (B) Wheatstone bridge. (C) Wheatstone bridge incorporating low value fixed resistance as two bridge arms, simulating carrier type of configuration.





Model H Miller oscillograph, 12 to 17 channels, 6 inch wide record.

balance controls. The sense of the change in strain is then obtained by adjusting the zero load balance point to half scale deflection of the galvanometer (which then may be repositioned mechanically to any point) by changing the resistance balance control. A tension strain would then cause a deflection opposite to a compression strain.

The inconvenience of the dual balancing system can largely be eliminated if a phase sensitive detector system is used. The unbalance voltage produced by a capacity unbalance is about 90° or 270° out of phase with the bridge supply voltage and will produce no steady output with this circuit. The unbalance voltage produced by the strain gauge is in phase or 180° out of phase with the supply voltage, depending on the sign of the strain. The direction of the current output of a phase sensitive detector changes as the reversal of phase of the bridge output voltage. The amplitude of the output current is directly proportional to the resistive unbalance. Electronically the phase sensitive unit consists of a conventional a.c. amplifier feeding into a ring demodulator. The ring demodulator is also excited by the bridge supply. In practice, unlimited capacitive unbalance is not practical; the out-of-phase signal is excessive, causing erratic phenomena or blocking of the amplifier.

An amplifier system to operate the galvanometers makes the oscillograph very versatile and is particularly useful where widely different sensitivities are necessary, or where the required sensitivity is not calculable. The amplifiers are adjusted to give the desired deflection on the record. A fictitious strain may be simulated by placing a resistor of known value across one leg of the bridge momentarily so as to produce a calibration of the amplifier and system on the oscillograph record.

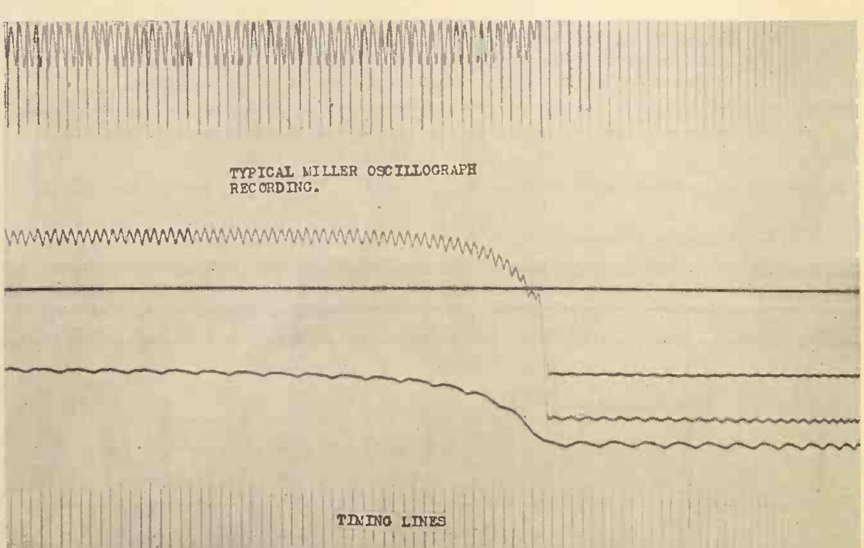
There are limitations on the carrier system of amplification. The upper limit range of useful carrier frequency is about 3000 cycles, since higher frequencies are excessively attenuated by the necessary shielding; also problems of intermodulation are more serious. Thus this system is limited to an upper frequency response of about 500 cycles. In transient studies the amplifier requirements are much more severe than that required for sinusoidal amplification. Theoretically a transient will be distorted if the amplifier does not pass an infinite band of frequencies. In practice the distortion can usually be limited so that results of engineering accuracy are obtainable with reasonably simple amplifier design. The low frequency limit of the amplifier depends upon the intelligence that is to be recorded. For static to quasi-static strains the amplifier (with detector) frequency response must be to zero cycles. The low frequency cut-off of amplifiers not having this range of coverage must not be too high or too rapid or confusing results may be observed due to "backlash." The upper frequency limit required of the amplifier is roughly that the rise time of the wave front to be recorded *must be greater* than one-half the upper frequency limit of the amplifier. This may be stated mathematically: Rise Time (sec) $>=$ ½ Upper Freq. Limit (c.p.s.).

The operation of galvanometers directly from a strain gauge bridge has numerous good and bad features depending upon the installation. It is desirable generally to use amplification, as no special problems exist as to gauge installations and the bridge output voltages are not critical, practically any installation allowing satisfactory recording of strain. However, where space and weight (or economic) factors dictate otherwise, it is possible in many cases to dispense with amplification.

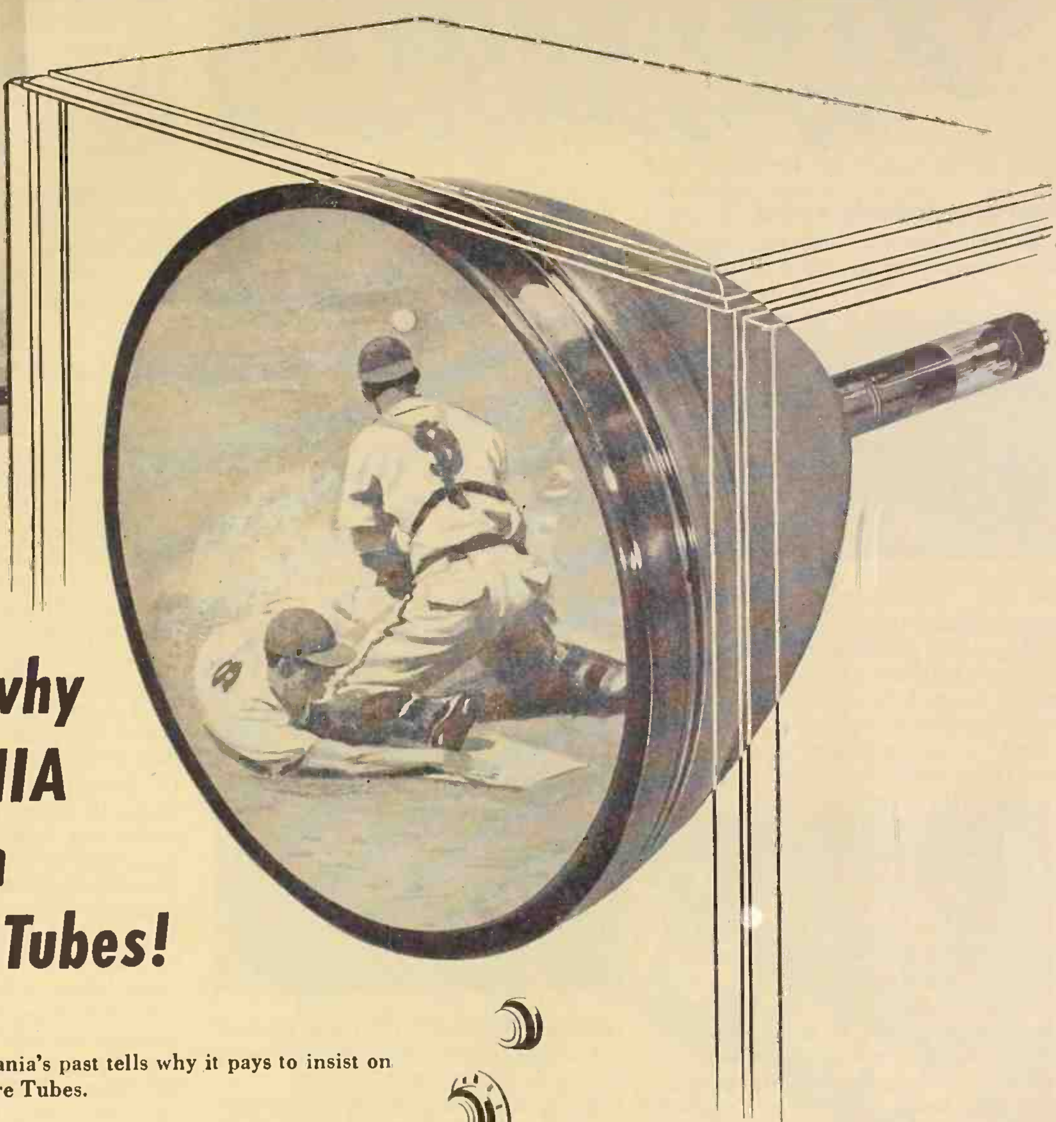
For many installations it is impossible to have more than one or two active legs in the bridge circuit; in all cases, the more active legs that can be employed, the better. Any given installation may also have more than one gauge in each arm. In such cases all gauges are made of equal resistance, connected in series or parallel. The effective unit change of resistance in that arm is then the average of that of all the gauges comprising the arm. The series connection would be simply the same as increasing the resistance value of a gauge, so that total series resistance in the arm would be used in any formula, the K remaining constant. The parallel connection is similar, but the parallel resistance value would be used with the formulas. This type of installation is of limited value, allowing in some cases closer imped-

(*Continued on page* 27A)

Typical strain gauge recording made with Miller oscillograph.



It takes Experience to make a Leader



That's why SYLVANIA leads in Picture Tubes!

A look at Sylvania's past tells why it pays to insist on Sylvania Picture Tubes.

Radio. For more than 25 years, Sylvania tubes have been noted for their fine performance and long life. Out of this experience has come a knowledge of electron behavior . . . clearer picture reception and Sylvania's famous ion trap now licensed to other leading picture tube makers.

Electronics. Sylvania's electronics background includes the designing of cathode-ray tubes, radar and other precision equipment for wartime use. From this has developed many of the modern advances in high-frequency techniques necessary for best TV reception.

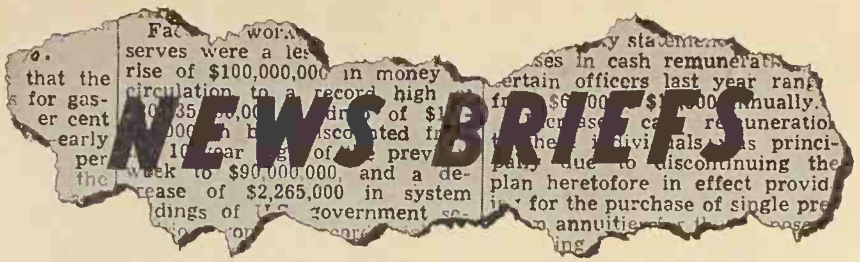
Phosphors. In the development of phosphors for the "Finest in Fluorescent Lamps," Sylvania has been an acknowledged leader for almost 20 years. This specialized experience is a basic reason for the smoothness and uniformity of Sylvania TV screens.

Lighting. Over half a century of experience lies behind Sylvania's lighting leadership. This includes years of research in filamentary wire, coiling and coating processes . . . further important reasons for the clarity and long life of Sylvania TV Picture Tubes.

For illustrated catalog giving ratings and engineering data concerning all Sylvania TV Picture Tubes, address: Sylvania Electric Products Inc., Dept. R-2309, Emporium, Pa.

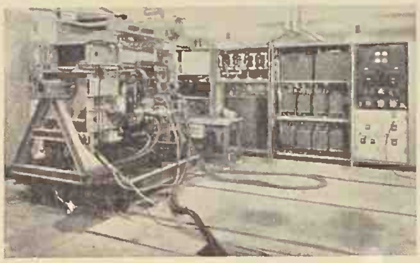
SYLVANIA ELECTRIC

RADIO TUBES; TELEVISION PICTURE TUBES; ELECTRONIC PRODUCTS; ELECTRONIC TEST EQUIPMENT; FLUORESCENT LAMPS, FIXTURES, SIGN TUBING, WIRING DEVICES; LIGHT BULBS; PHOTOLAMPS; TELEVISION SETS



BETATRON INSTALLED AT NBS

A 50-million volt betatron, designed and constructed by *General Electric*,



has been installed in the National Bureau of Standards' new betatron laboratory. This installation extends the Bureau's high-energy research into the region from 2 to 50 million electron volts, and for work at even higher energies, a 180-million-volt synchroton now being completed by *GE* will be installed at the Bureau next year.

The NBS research program with these machines has four main aspects: the investigation of shielding and protection against high-energy radiations, the medical applications of these radiations, their industrial applications, and their basic physical properties.

The new betatron laboratory, housing the 50-million volt betatron and adequate for the coming 180-million volt synchrotron, is made of reinforced concrete with walls varying in thickness between 2 and 8 feet. For studies of protective shielding, beams can be passed into a special radiation room through barriers up to 10 feet in thickness. The beam can also be taken out of doors for a distance of about 500 yards.

PACIFIC ELECTRONIC EXHIBIT

The 6th Annual Pacific Electronic Exhibit, to be held in the Municipal Auditorium, Long Beach, California, September 13-15, is expected to be the largest and most diversified display of electronic materials and equipment ever shown in the West at one time.

A recent survey among 2200 industrial concerns, all classed in trade fields other than radio, electronic or electrical, disclosed the ever-increasing general interest to all industry. The relative value of operating supplies now purchased annually by industrial concerns is: 53% Mill Supplies; 30% Electrical Supplies; and 17% Electronic Supplies.

The Annual West Coast Convention of the Institute of Radio Engineers will be held at the same time and same place.

MARINE RADAR

The Marine Exchange lookout station at the end of Meigg's Wharf in San Francisco is now equipped with a new *Westinghouse* type MU-1 marine radar set for harbor surveillance work.

The long glass, used since 1901 to spot and identify ships entering and leaving San Francisco Bay, was adequate when the weather was good, but the radar will provide an accurate and

reliable determination of the position of any object within range regardless of fog, rain, or darkness.

With its antenna located in a weatherproof radome on top of the lookout station, the radar equipment can "see" vessels outside the Golden Gate as well as in the harbor north of the Bay Bridge. Although this installation of radar is intended only for observation of harbor traffic, it is possible to utilize the information provided by the radar set for purposes of harbor control, as is now being done in a few other harbors.

ELECTRONIC NAVIGATION SYSTEMS

New types of electronic systems which have the ability to store and recognize information in a manner similar to that of the human mind were revealed by Nathan Marchand and M. Leifer of the Physics Laboratories of *Sylvania Electric Products Inc.*, at the meeting of the International Radio Scientific Union recently.

According to the *Sylvania* scientists, the rapid response of the electronic mechanism makes it particularly useful where rapid calculations are needed as in radar, sonar, and aircraft navigation. The electronic apparatus, which they described, operates through the use of a particular periodic signal which may be distinguished from all other signals by its characteristics. These distinctive characteristics include distribution of amplitudes, frequencies and phase of the modulation sidebands. Recognition of a particular signal with a high degree of certainty can be accomplished by correlating the received signal characteristic with that of a stored signal in the receiver.

NAS TO MEET

Dr. A. N. Richards, President of The National Academy of Sciences, has announced that its autumn meeting will be held at the new quarters of the *General Electric Research Laboratory* near Schenectady, N. Y. beginning Monday afternoon, October 9th.

Scientific papers will be presented on Tuesday, October 10th, and Wednesday afternoon, October 11, will be devoted to inspection trips through the various laboratory buildings, as well as the new *GE* turbine building at the Schenectady Works. A public lecture in Memorial Chapel, Union College, will be given by Dr. Cornelius P. Rhoads, director of the Memorial Hospital Center for Cancer and Allied Disease in New York, and there will be a reception at the Hotel Van Curler on Wednesday evening. Sir Lawrence Bragg, director of the Cavendish Laboratory at Cambridge University, will be the principal speaker at the dinner which follows.

General Electric scientists who are members of the National Academy of Sciences are: Dr. Willis R. Whitney, Dr. William D. Coolidge, Dr. C. G. Suits, Dr. Irving Langmuir, Dr. Albert W. Hull, and Dr. Zay Jeffries.

PHOTOGRAPH SOUND WAVE PATTERN

Scientists at the *Bell Telephone Laboratories* have developed a new technique

whereby actual photographs of the pattern of sound waves can be obtained. Equipment used in the work consists of a tiny microphone and a neon lamp, mounted on a swinging beam which scans the wave field. As the beam moves through the field, a clear picture of the sound radiation is built up by scanning, similar to the way television images are formed.

F. K. Harvey, who with W. E. Kock developed the new technique, demonstrates the focusing effect of an acoustic lens on sound waves emitted from the horn at left.

This method will be used for studying the sound waves from telephone receivers and similar communications equipment, and for observing microwave radio wave patterns.

MICROWAVE EQUIPMENT ON POWER LINE

The satisfactory use of microwave and multiplex equipment for communication between a Pennsylvania generating station and system operating headquarters was reported at the recent Summer and Pacific General Meeting of the AIEE in Pasadena, California.

In a technical paper, four engineers described the communications method on the *Pennsylvania Electric Company* power lines from the Seward generating plant to the system operator at Johnstown, Pa., 12 miles away. As a result of the successful year's test, plans are being made to permanently control the entire Seward station switchyard from the load dispatcher's office at Johnstown using the microwave channel.

The microwave channel was described as a beamed high-frequency radio communication medium, which can be used to transmit from point-to-point, the intelligence required in the normal operation of a power system. The Pennsylvania experiment involved use of three two-way voice channels, two different types of protective relaying, two telemetered quantities and supervisory control of eight points.

Authors of the paper were D. R. Pattison of the *Pennsylvania Electric Co.;* M. E. Regan, S. C. Leyland, and F. B. Gunter, all of *Westinghouse.*

NEW LITERATURE

Aeronautical Letter Symbols

The American Standards Association has announced a new American Standard Letter Symbols for Aeronautical Sciences. It recommends standard letter symbols for 400 primary and secondary concepts, many of which are in agreement with American Standards for other phases of science and engineering.

The new document consists of two main tables: the first alphabetical by symbols and the second alphabetical by concepts. Also included in the first table for convenience in using the standard are (1) the dimensional characteristics of the various concepts in terms of mass, length, time and temperature, (2) indications of agreement with other current American Standards, and (3) helpful remarks and definitions.

Copies of American Standard Letter Symbols for Aeronautical Sciences, Z10.7-1950, may be obtained from the American Standards Association, 70 East 45th St., New York 17, N. Y. at $1.25 per copy.

Study of Research Personnel

The American Institute for Research under the sponsorship of the Scientific Personnel Advisory Committee of the American Council on Education has published a study on "Critical Requirements for Research Personnel" as an aid in the selection, training, and evaluation of research workers.

The data collected consists primarily of objective reports of the activities of research workers on the job. A large and representative sample of about 500 research workers supplied more than 2500 such critical incidents. Separate appendices have been prepared for this report which contain illustrations and detailed discussion of procedures, as well as more complete data primarily of technical interest.

Both the report and the appendices may be obtained from the American Institute for Research, 413 Morewood Ave., Pittsburgh 13, Pa., free of charge.

Survey of Power Sources

A comprehensive survey of power sources contained in a three-volume study covering both electrical and non-electrical devices, prepared by the Armour Research Foundation for the Signal Corps, is now available.

The study is concerned with methods of generating electric power, including various prime movers suitable for this purpose. Volume I deals with the predominant use of electromagnetic generators for power production. Volume II covers electrostatic generators, and the third volume covers prime movers.

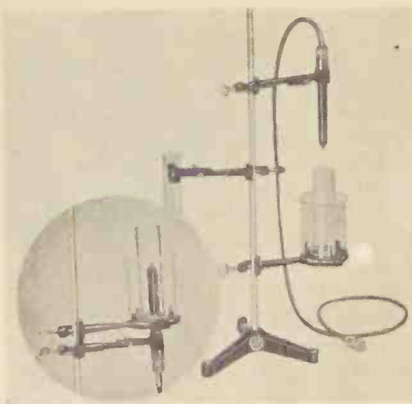
The three volumes, under the title of "Survey of Power Sources," are available separately as follows: Volume I, $15.85; Volume II, $11.30; and Volume III, $12.50, all in ozalid form. Orders should be addressed to the Armour Research Foundation, Technology Center, Chicago 16, Illinois.

The Library of Congress, Photoduplication Service, Publication Board Project, Washington 25, D. C., can supply microfilms of the three volumes (listed in order) as follows: PB 98588, $9; PB 98589, $7; PB 98590, $8.

NEW PRODUCTS

LIQUID COUNTER

A special set of equipment to speed up counting work and simplify laboratory work with solutions containing ra-



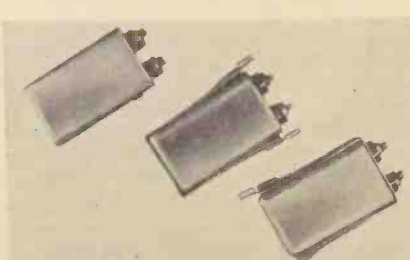
dioactive materials is now available from *Nuclear Instrument and Chemical Corporation*, 229 West Erie St., Chicago 10, Illinois.

In addition to standard laboratory pieces, such as ring stand and necessary clamps, the set also includes a special Marinelli type beaker and a support on which the beaker can be mounted. A plug-in type counter is provided with the set over which the Marinelli beaker can be placed.

As part of this set, a test tube of correct size is also provided so that the Geiger tube may be used as a dip counter. For beta counting the test tube is filled with 20 cc. of the active liquid which then covers the sensitive area of the counter. This counter is all glass and is easily decontaminated.

ZERO TEMP. COEFFICIENT CAPACITORS

Condenser Products Company, 1375 North Branch St., Chicago 22, Illinois,



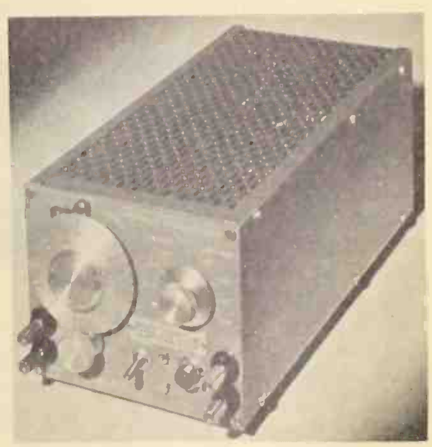
is now manufacturing zero temperature coefficient capacitors.

Plasticon AS Capacitors have a positive temperature coefficient of 1000 parts per million per degree Centigrade. Plasticon LS Capacitors are negative 1000 ppm/°C. By combining matched capacitor elements of each type in a single container, temperature coefficients from plus 1000 ppm/°C to minus 1000 ppm/°C can be supplied.

Readers having engineering problems, or in need of further information, may write *Condenser Products Company* direct.

ELECTRONIC FILTER

Spencer-Kennedy Laboratories, Inc., 186 Massachusetts Ave., Cambridge 39, Mass., now has available Model 300 Variable Electronic Filter which has a continuously variable cut-off within the frequency range of 20 cycles per second to 200 kc. With an attenuation rate of



18 db. per octave it is analogous in performance characteristics to the Constant-K inductance-capacitance filter.

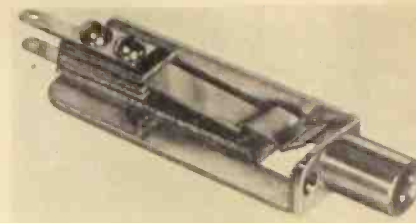
A range switch selects the type of section desired, high-pass or low-pass, as well as four decade frequency ranges. Several filters can be cascaded so that attenuation rates of 36, 54, etc. db. per octave can be realized. Sections can be combined to make a variable band-pass filter.

Further information may be obtained by addressing inquiry to Dept. RT.

TELEPHONE-TYPE JACK

Cinema Engineering Co., 1510 W. Verdugo Ave., Burbank, California, has announced a tooled telephone-type jack for patch panels incorporating the use of nickel-silver contact springs, pure silver contact, and 1/16th inch frame.

Catalog number of this jack is 1399-B. It can be used in standard *Western*



Electric and Cinema-type jack mounting strips. Distribution of this new jack will be through factory representatives, distributors, and also direct from the Burbank factory.

DELAY LINES

Shallcross Manufacturing Company, Collingdale, Pa., is now offering lumped delay lines tailored to specific applications.

A typical unit consists of eight pie-section low-loss filters having a rise time of 0.04 microseconds and a total delay of 0.3 microseconds. Maximum pulse voltage is ± 100 volts and impedance is 500 ohms. The cut-off frequency is 8.5 megacycles and the maximum operating frequency is approximately 2 megacycles based on a pulse delay error of not more than 2%. The unit consists of eight universally-wound coils of 3-strand #41 Litz wire and nine low temperature coefficient silver mica capacitors.

Many other types of delay lines can be supplied to order.

RADIATION MONITOR

The Kelley-Koett Mfg. Co., 159 E. Sixth St., Covington, Kentucky, has announced a new a.c. operated radiation monitor for use in isotope laboratories to determine simply and quickly the

contamination of laboratory accessories, benches, and hands.

The K-900 Radiation Monitor comes equipped with the Keleket Model K-23.

aluminum thin-wall Geiger tube, sensitive to both beta and gamma radiation, and mounted in a probe connected to the main cabinet by a self-retracting cord for laboratory convenience. An easy-to-read meter indicates either radiation rates or high voltage applied to the Geiger tube. A range and H. V. switch on front panel selects either one of two ranges: 10,000 (x10) or 1000 (x1) counts per minute, full scale. The Geiger tube voltage is adjustable from 500 to 1000 volts.

Further details on this unit may be obtained upon request to The Instrument Division.

TELEVISION TRANSMITTER

General Electric Co., Syracuse, N. Y., has announced a self-contained, air-cooled television transmitter, type TT-10-A, designed to provide low installa-

tion, operating and maintenance costs. The new 5 kw. unit has a 5 kw. visual transmitter and a 2.5 kw. aural transmitter in three cubicles and is for operation on TV channels 2 through 6.

Features of the new unit are outstanding video and r.f. circuits in addition to the latest in control circuit design. No external transformers or cooling equipment are required. A simplified visual modulator incorporates features such as back porch type clamp d.c. insertion, controllable sync stretching, picture face control, adjustable white clipper, and smaller size.

Further information on this transmitter may be obtained from the *GE* Commercial Equipment Division at Electronics Park, Syracuse, N. Y.

MU-BETA EFFECT CALCULATOR

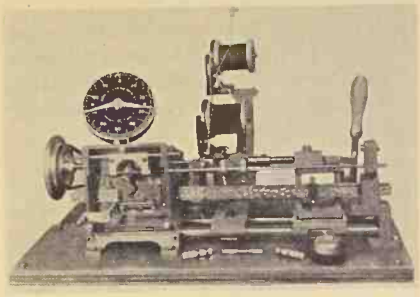
Graphimatics, 201 North Taylor, Kirkwood 22, Missouri, has announced its Mu-Beta Effect Calculator for reading complicated feedback functions with about the same ease that a simple product is read from a conventional slide rule.

The 10-inch calculator is cut from a solid disk of vinylite, protected by a chemically deposited transparent surface. Complete instructions and five examples of the use of the calculator are printed on the reverse side.

Literature describing the calculator is available upon request.

COIL WINDING MACHINE

A coil winding machine that winds coils and selenoids up to 8″ in length



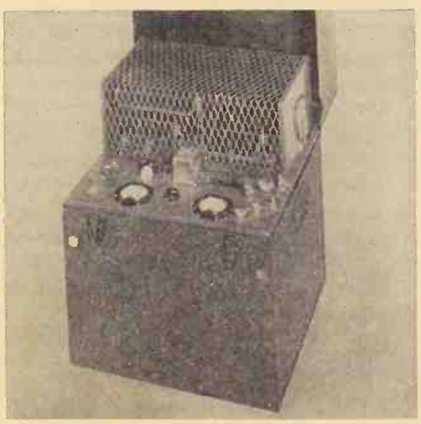
instead of 6″ is announced by *Geo. Stevens Mfg. Co., Inc.*, 6022 No. Rogers, Chicago 30, Illinois. Model 125 is mounted on rods instead of a cast iron base, and the tension bracket may now be moved to any position to suit the winding arbor.

This model also winds progressive universal coils up to 4″ in length and 3″ in diameter, universal coils up to ¾″ in width, and L.F. coils; winds wire from 20 to 44 gauge. Standard equipment includes: ¼ h.p. universal motor, foot operated speed controller, V belt drive, and double spool carrier with two adjustable oilite bearings to control wire during winding.

A dial counter (Model 50 or 51) with 6″ full vision clock dial which accurately registers all turns is also available.

REGULATED POWER SUPPLY

A compact, portable, closely regulated power supply for use in testing laboratories, on production lines, for



testing radio communication and electrical equipment in airplanes, etc., has been developed by *The Richardson-Allen Corporation*, 15 West 20th St., New York, N. Y.

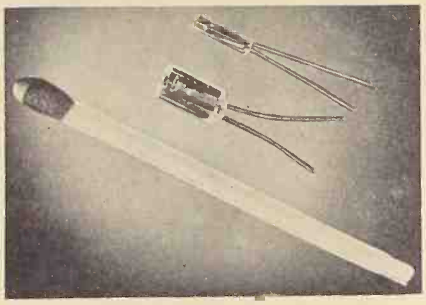
This unit has a selenium rectifier, full

(*Continued on page* 31A)

NEW TUBES

SUBMINIATURE PHOTOCELL

Sylvania Electric Products, Inc., Bayside, N. Y., has developed a tiny, inexpensive photocell which utilizes the



photosensitivity of germanium. This new photoelectric device is described as being essentially a germanium diode especially designed to permit use of the photoelectric properties of germanium and similar semiconductors. The average sensitivity of the unit in the point-contact region is reported to be about a tenth of a milliampere change in current per lumen for light in the near infrared region.

It is expected that these subminiature photoelectric devices will find wide use in such applications as decoding punched tape, electronic computing and sorting, and in the direct operation of relays such as for opening and closing doors.

At the present time these devices are still in the laboratory stage and plans have not been completed for quantity production.

RECTANGULAR TV TUBE

The Tube Division of *Allen B. Du Mont Laboratories, Inc.*, 750 Bloomfield Ave., Clifton, N. J., is announcing a new rectangular cathode-ray television

picture tube, featuring the exclusive *Du Mont* bent-gun design which assures a sharper spot focus and at the same time provides protection from ion spot blemishes. A gray filter face-plate is used for improvement of contrast in the presence of ambient light.

Designed as initial equipment, or as a conversion tube, the Type 16TP4 makes possible a picture 14⅞" wide including all the scanning area of the transmitted signal. As a conversion tube, the Type 16TP4 can provide a larger, rectangular picture in existing cabinets than original round tube equipment.

GE TUBES

Miniature Receiving Tubes

General Electric Company, Schenectady, N. Y., has announced two new miniature tubes designed primarily for television and radio receivers.

The 6S4 is a high perveance medium-mu triode for use as a vertical-deflection amplifier in television receivers which employ picture tubes having a deflection angle up to 70 degrees and operating at anode voltages up to 14,000 volts.

Ratings include a d.c. plate voltage of 500 volts; a peak positive surge plate voltage of 2000 volts; and a plate dissipation of 7.5 watts.

The 6AH6 is a sharp cut-off amplifier pentode. Its high transconductance and low input and output capacitances adapt it to use as a wide-band amplifier and as a reactance tube for television and radio receivers. Under typical operating conditions it has a transconductance of 9000 micromhos and plate current of 10 milliamperes.

Twin Triode

A twin triode, for use as a combined vertical oscillator and vertical-deflection amplifier in television receivers, has also been added to *General Electric's* tube production lines. The new tube, the 6SN7-GTA, is electrically and mechanically interchangeable with its prototype, the 6SN7-GT.

The plate dissipation rating has been increased to 7.5 watts for both plates in the 6SN7-GTA. The plate voltage rating has been increased from 300 to 500 volts, and the heater-cathode rating has been increased from 90 to 200 volts. This tube carries a peak positive-pulse plate voltage rating of 1250 volts and a peak negative-pulse grid voltage rating of 200 volts for television applications.

MINIATURE RECTIFIER

Hytron Radio & Electronics Corp., Salem, Mass., has designed a miniature filamentary-type rectifier for use in television sets as a high-voltage rectifier supplying power to the anode of the cathode-ray tube.

The 1X2A, having higher ratings than the 1X2, is designed and rated primarily for use in fly-back type of power supplies. In new equipment applications the 1X2A, when used within its maximum ratings, is a replacement for type 1B3GT/8016 at d.c. output potentials as high as 14 to 15 kilovolts.

16" TV PICTURE TUBE

Also announced by *Sylvania* is a sixteen-inch metal television viewing tube which is five inches shorter than the 16AP4. The tube, type 16GP4, is also ¼" shorter than the standard 10" types.

Deflection angle is 70 degrees, or approximately 15 degrees greater than prior types of the same screen diameter. The tube is supplied with a neutral gray face plate to improve picture contrast, particularly in the presence of high ambient light levels.

RCA TUBES

U.H.F. Triode

One of the many tubes announced by the Tube Department of *RCA*, Harrison, N. J., is the 5876 high-mu, "pencil type" triode designed for use in grounded-grid circuits. It is particularly useful as an r.f. amplifier, i.f. amplifier, or mixer tube in receivers operating at frequencies up to about 1000 mc., as a frequency multiplier up to about 1500 mc., and as an oscillator up to 1700 mc.

As an unmodulated class C r.f. amplifier, the 5876 is capable of giving a useful output of 5 watts at 500 mc. As an unmodulated class C oscillator, the 5876 can deliver a useful power output of 3 watts at 500 mc. and 750 milliwatts at 1700 mc.

This design employs a coaxial-electrode structure of the double-ended type.

7" Oscillograph Tube

Among the other new tubes announced by the Tube Department of *Radio Corporation of America*, Harrison, N. J.,

is the 7MP7, a 7" cathode-ray tube of the magnetic-deflection and magnetic-focus type having a long-persistence, cascade (two-layer) screen. It is intended primarily for pulse-modulated applications, such as radar indicator service, and replaces the 7BP7-A in new equipment design.

Features of the 7MP7 include a limiting aperture at the end of the electron gun to provide greater effective resolution, a face plate of television quality, a neck diameter of 1$\frac{7}{16}$", and a small-shell duodecal 5-pin base.

Miniatures for Computer Service

RCA has just made available to industrial equipment designers three new miniature tubes for use in "on-off" control applications, such as electronic computers involving long periods of operation under cut-off conditions.

The 5915 is a pentagrid amplifier of the 7-pin miniature type designed espe-

cially for gated-amplifier service. Grids No. 1 and No. 3 can each be used as independent control electrodes.

The 5963 is a medium-mu twin triode of the 9-pin miniature type intended particularly for frequency-divider circuits. It has a mid-tapped heater to permit operation from either a 6.3 volt or 12.6 volt supply, and separate terminals for each cathode to provide flexibility of circuit arrangement. It has a maximum plate dissipation of 2.5 watts.

The 5964 is a medium-mu twin triode of the 7-pin miniature type for use in frequency-divider circuits. Its cathode is common to the two triode units. The maximum plate dissipation is 1.5 watts.

Sharp cut-off Pentode

The new *RCA*-5879 announced is a sharp cut-off pentode of the 9-pin miniature type intended for use as an audio

amplifier in applications requiring reduced audio noise.

This tube utilizes a single-ended structure which is relatively short and rigidly mounted to minimize microphonics, a controlled getter deposit to minimize internal leakage, and a double-helical-coil heater to minimize hum. The 5879 is especially recommended for service in the input stages of medium-gain public-address systems, home sound recorders, and general-purpose audio amplifiers.

FIVE MINIATURE TUBES

General Electric has added five new types of miniature tubes to its product lines.

The 5749, a miniature remote cut-off pentode, is used as a radio-frequency and intermediate-frequency amplifier. The 5750, a miniature pentagrid converter, is used as a combined oscillator and mixer in superheterodyne receivers.

The 5725 is a miniature semi-remote cut-off pentode for use in gated ampli-

(*Continued on page* 26A)

Personals

HARRY ESTERSOHN, associate of the *M. J. Shapp Company*, will represent *Meissner Manufacturing* Div. of *Maguire Industries, Racon Electric Co., Dalco Manufacturing Co., Herman Hosmer Scott*, and *Switchcraft, Inc.* A graduate of the Miami University, Mr. Estersohn has been in the radio business for over ten years and for several years was associated with New York Jobbers specializing in Sales Engineering and Advertising.

JOHN A. GREEN, formerly Head of *Collins Radio Company's* broadcast engineering department, has established the *John A. Green Company*, manufacturers' representatives, and the *Equipment & Service Company*, consulting engineers and electrical manufacturers, at 6815 Oriole Drive, Dallas, Texas. Mr. Green is a Senior Member of the IRE, a member of the AIEE, and the American Petroleum Institute, and a licensed Professional Engineer in Oklahoma.

RICHARD G. LEITNER, who for the past four years has been chief engineer of the *Lear, Inc.*, California division, has resigned to take a similar post with the *U. S. Electronics Corporation*, Los Angeles, California. Mr. Leitner is a founder member of the Electronic Club of Los Angeles; a director of WCEMA and is also a member of the WCEMA executive show committee to arrange the 6th Annual Pacific Electronic Exhibit.

WILLIAM H. MILTON, JR., has resigned as *General Electric* commercial vice president to become general manager of the Knolls Atomic Power Laboratory, operated by *GE* near Schenectady for the Atomic Energy Commission. Mr. Milton will be in charge of the over-all organization, operation, and program of the laboratory. He is a graduate of the Virginia Military Institute with a B.S. degree in electrical engineering and joined *GE* in 1920.

FRANCIS X. RETTENMEYER, has joined *Philco Corporation* as executive engineer to assist in the engineering administration of the company's Government and industrial electronics program. Mr. Rettenmeyer was associated with the *Bell Telephone Laboratories* for ten years, was with *RCA* as chief receiver engineer in the home instrument division, and for the past five years has been chief engineer for *Federal Radio and Telegraph Company.*

DR. ERIC WALKER has become Executive Secretary of the Research and Development Board, Department of Defense, Washington, D. C. Dr. Walker, who has succeeded Dr. Robert F. Rinehart, is on leave from Pennsylvania State College where he is director of the Ordnance Research Laboratory and the head of the Electrical Engineering Department. During the war, Dr. Walker was assistant director of the Underwater Sound Laboratory at Harvard.

New Tubes

(*Continued from page* 25A)

fiers, gain-controlled amplifiers, delay circuits, and mixer circuits. The 5726, a miniature twin diode, may be used as an AM-FM detector, automatic-volume-control rectifier, and low-current power rectifier. The 5686, a miniature pentode power amplifier, is used as a Class A audio power amplifier or Class C radio-frequency power amplifier up to 160 megacycles.

Further information on these tubes may be obtained from the Tube Divisions, *General Electric Company*, Schenectady, N. Y.

Magnetic Clutch

(*Continued from page* 13A)

torque on heating all disappear.

The ultimate temperature limit then becomes the Curie point of the iron powder (over 500°C.). The disadvantages associated with the use of dry powder are as follows:

1. The transition from static to kinetic friction is not quite as smooth as that obtained with magnetic fluid.
2. Depending on the rotor design, the use of the iron-oil mixture may result in 10 to 15% higher output torque for a given coil current. Subsequent experiments have shown that with a rotor designed expressly for powder, there is no difference in output torque between fluid and dry powder.
3. Heat transfer from powder to metal portions of clutch is not as good as that obtained with a fluid, due to the lack of continuous intimate contact between particles and fluid.
4. The use of rotor slots decreases the available rotor area for a given over-all dimension. Since the rotor contributes only a small percentage of the over-all size of the clutch this is not considered significant.
5. Oxidation of the powder due to high temperatures. Since the permeability of carbonyl powder is greater than that of the iron oxides, continued oxidation results in a reduction of output torque.

The circuit which utilizes the two clutch drives for automatic tuning is shown in Fig. 4. With the exception of the chopper type amplifier and the new clutch drive, the radio frequency circuitry is similar to that previously published.[1,2]

Credit is due Mr. L. H. Davis and Mr. G. H. Webber of the *RCA-Victor Division*, Camden, N. J. for their valuable assistance in the successful completion of this development.

REFERENCES

1. *Wald, S., "Automatic Tuning,"* RADIO-ELECTRONIC ENGINEERING, *May* 1949.
2. *Wald, S., "D.C. Operated Servo-Amplifier,"* RADIO-ELECTRONIC ENGINEERING, *August*, 1948.

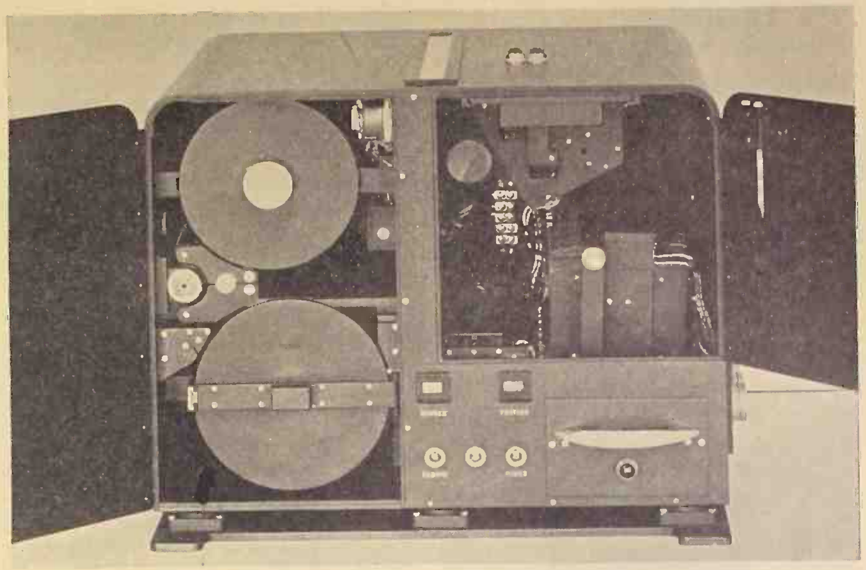
Oscillographic

(*Continued from page* 18A)

ance matching of the bridge to the galvanometer. The number of gauges per arm is limited by consideration of the strain gradient over the area required for installation of the gauges. Transverse, bending, and shear type installations allow four active bridge arms. In these installations it is a question whether to use two active legs (where space is insufficient for four) with several gauges in each of these arms or install a full active bridge. The first method would possibly allow closer impedance matching, while giving one-half the voltage output available from the full bridge. In any case, it is generally best to mismatch the bridge leg resistance higher than the galvanometer resistance in order to secure a closer match to the proper shunting resistance for critical damping. All methods should be calculated and the most suitable used. The effective shunting impedance of a standard Wheatstone bridge to its galvanometer is the resistance value of one of the four legs or arms.

Three types of bridges may be used in this application, a battery bridge, or two versions of the Wheatstone bridge. The battery bridge gets its name from the circuit configuration. The battery is tapped off at the center of its cells to give an equipotential point for the galvanometer connection, as shown in Fig. 4A. This system is not satisfactory unless zero strain calibration points may be checked frequently, because unequal drifts of cell potentials on either side of the center tap will cause indication of a strain signal when one is not present. The best galvanometer impedance match for this circuit is when the galvanometer resistance is twice the resistance of either leg of the bridge or $2\ R_g = R_1$ (or R_2). The Wheatstone bridge in both versions has four resistive arms, one wired to the standard configuration. The other version attempts to simulate a carrier operated system wherein all the gauges are fed with a center-tapped transformer. Here the center-tapped transformer is replaced with a center-tapped resistor, of low value, and it is a common return for all the half-bridge gauges as indicated in Fig. 4C. The common half-bridge connection gives rise to serious cross-talk problems in the same ratio of any one channel's output current to the total bridge current in the low resistance leg. A certain amount of cancellation cross-talk will occur in a multi-channel installation.

The full Wheatstone bridge may consist of any number of active gauges, with from one to three dummy gauges per channel, where all four gauges are



Light weight multi-channel oscillograph especially suited for aircraft use.

not active. The calculations for this type of installation are comparatively simple. The relationship of galvanometer resistance to bridge arm resistance for maximum sensitivity for this type of bridge is unity. The galvanometer deflection values are stated by the oscillograph manufacturer, for a given instrument, in terms of "amperes per inch" deflection on the record. The galvanometer current for a given strain may be found by the formula:

$$I_{gal} = dE_o/Z_o$$

where $dE_o = (N_a/2)\ R_g\ I_g\ Kds$, and where R_g and I_g are respectively the gauge resistance (or effective value with more than one gauge) and the current (in amperes) flowing through it. K is the gauge factor, dS is the strain in inches/inch, and N_a the number of active gauges. Z_o is the resistance of the galvanometer plus the resistance of one leg of the bridge. The resistance of the galvanometer leads must be added to the galvanometer resistance if the lead resistance amounts to any appreciable percentage of Z_o. Where the expected (or actual) strain will cause insufficient deflection even with optimum impedance matching, then the bridge voltage may be set to the highest value allowable, but not to exceed one-half watt dissipation per gauge. Excessive deflection may be remedied by lowering the bridge supply voltage (and gauge current) or by purposely mismatching the bridge galvanometer.

The deflection may be interpreted directly into terms of strain where calibration has been made with a resistance placed across one arm of the bridge momentarily to simulate a resistance change with strain. Here the deflection for the simulated strain would be substituted in the following formula to give actual strain as shown by the oscillograph record:

$$dS = \frac{\text{Deflect.} \times dS_s}{\text{Deflect.}_s}$$

where the subscript s means simulated.

The bridge should be wired with a balancing control, and preferrably a calibration circuit, as outlined in previous articles.

TV Impulse

(Continued from page 7A)

modulation control is adjusted for a reasonable picture output.

The next adjustment to be considered is that of the pulse output height. This is controlled by means of the toggle switch attenuator on the top panel of the apparatus. By means of a calibration chart, the attenuator may be set for an impulse of any desired height.

The impulse phasing switch may be adjusted to obtain either white or black impulse noise. (See Fig. 7.) The effect of the impulse on the receiver also depends on the level of the impulse noise relative to the transmitted signal.

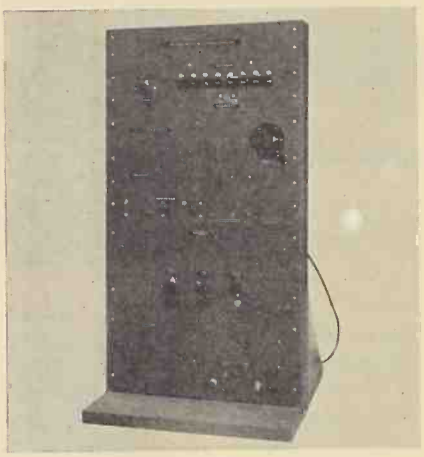


Fig. 6. Front view of generator.

The adjustment of the pulse positioner is mostly visual. As the test pattern is observed on the picture tube of the receiver under test, the step controls and the fine adjustment knobs on the vertical positioner, horizontal positioner, and group-length control on the front of the pulse positioner may be set to place the impulse noise effects where desired.

The Impulse Interference Generator has been used to test television receivers using the blocking oscillator type of sync circuits and also the automatic frequency control type. The device allows one to observe exactly how the synchronizing circuits are affected by noise impulses. (See Fig. 8.) With the blocking oscillator type of sync circuits, only the lines which are pulsed are disturbed. With the automatic frequency control type, one can watch the action of the phase detector and the sync bias, and see how the sync is pulled out and also determine the recovery time necessary for stable operation. If the amplitude and phase of the transmitted signal and the noise impulse are independently controlled, a number of different operating conditions can be simulated. The equipment promises to be a useful research tool for studying impulse-noise effects, particularly under conditions of low signal strength.

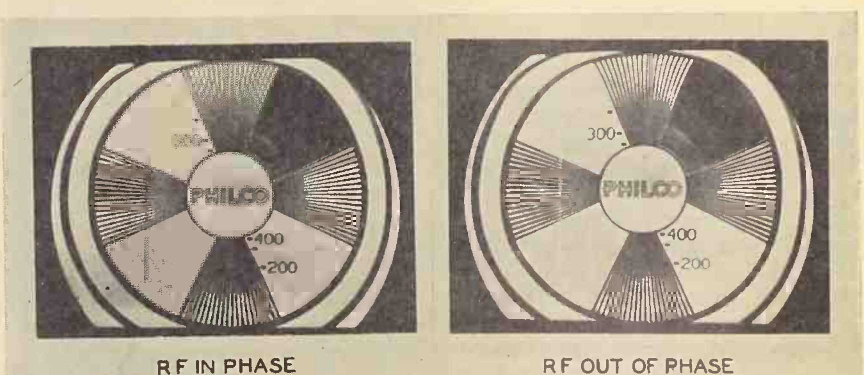
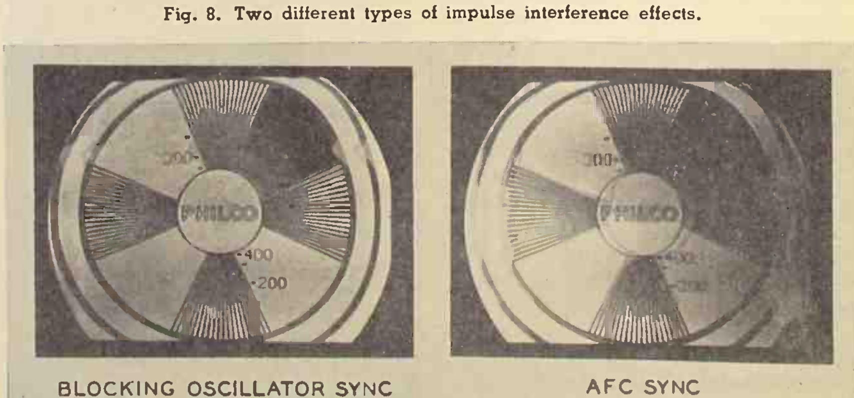


Fig. 7. Impulse group in picture with a 0.1 microsecond pulse width.

Fig. 8. Two different types of impulse interference effects.



TECHNICAL BOOKS

"THE ELECTRONIC ENGINEERING MASTER INDEX" 1947-1948. Published by *Electronics Research Publishing Co., Inc.*, 480 Canal St. New York 13, N. Y. 339 pages. $19.50.

This subject index for the years 1947-1948 is the third volume in the series covering electronic and allied engineering literature published throughout the world since 1925. It contains more than 18,000 new entries, and indexes almost three times the number of publications listed in previous volumes.

Two entirely new sources for reference have been included in this volume: the 5500 electronic and allied patents issued by the U. S. Patent Office during 1947-1948, and the declassified documents published by the U.S., British, and Canadian governments. This listing makes available much of the important war and postwar research in electronics, atomic physics, and allied fields. Included is the important work done at the M.I.T. Radiation Laboratory, Naval Research Laboratories, and universities and colleges throughout the country.

Patents are listed, in numerical sequence, under subject headings and patent references have been included with the bibliographical listings to correlate the described and patent phases of the art.

The cumulative cross index of subjects at the end of the book has been greatly expanded and serves as a guide to the present compilation, the 1924-45 edition, and the 1946 edition.

"OCEAN ELECTRONIC NAVIGATIONAL AIDS" Revised Edition, United States Coast Guard, Published by the U. S. Government Printing Office, Washington, D. C. 73 pages. 50¢.

This booklet contains information on Loran, radiobeacons, microwave beacons, Radar reflectors, and Radar, and was prepared to answer the many inquiries received by the United States Coast Guard on these subjects.

Included in the pamphlet are advisory minimum specifications for marine Radar, Loran receiving equipment, and direction-finder equipment. These advisory specifications are promulgated for the use of those interested in electronic navigational aid equipment, and are intended only as a guide for voluntary use.

The United States maritime industry, commercial airlines, and others interested in the application of electronic navigational aids will find this material beneficial in improving the safety, economy, and efficiency of transportation over the areas of the world.

U.H.F. TV

(*Continued from page* 14A)

It is not necessary to have a separate u.h.f. carrier frequency for each program channel since the one u.h.f. carrier and its various modulation sidebands, all from one transmitter, provide adequate input for the crystal detector to give appropriate demodulation products which are regular v.h.f. signals for the standard TV receiver. It thus becomes possible for one transmitter to provide at least seven channels of television service to its locality. The reason for seven channels is that this corresponds to the plan of allocation now used by the FCC for v.h.f. allocations. An alternate way of generating the u.h.f. signals, with simpler modulation methods, would be to use a single strong carrier in the u.h.f. region with additional u.h.f. transmitters to furnish the sidebands. The strong carrier is used to beat against these transmitters to produce the proper signal in the television receiver. These sideband transmitters are spaced in the spectrum such that the frequency differences between the strong carrier and each of the sidebands correspond to the frequencies of channels 2, 3, 4, etc.

Since several programs are thus carried on one transmitter, the costs for station power, maintenance, etc., can be shared, so that the cost of maintaining such a multi-program television station is reduced to only slightly more than for a conventional single-program station. There is also an equipment economy; for example, it is obvious that only one generator for making the standard RMA waveform would be required for all local programs.

The single transmitter location greatly reduces the problems associated with the highly directive receiving antennas, since orienting the antenna for one channel gives all channels. This does not prevent the radiation from the one transmitter being directed especially to those areas that it is desired to serve best. For example, a town lying along a valley would have a transmitting antenna radiating its energy in one or two beams along the valley so as to serve the greatest number of people with a strong signal.

While this system involves the use of a relatively insensitive crystal detector mounted at the antenna, the sensitivity problem is not acute, since the intention is to supply short-range distances for which the received energy would be strong enough to give good detector efficiency. If the transmitted carrier is made a number of times stronger than the sidebands, quasi-superheterodyne operation in the crystal takes place with the "local oscillator" being supplied by the u.h.f. carrier from the transmitter; then increased receiving sensitivity can be obtained. While the present powers used on the u.h.f. television frequencies are low, it would seem that following the past history of such developments, radiated powers of from 50 to 100 kw. are not too far away, making this system effective up to 15 or 20 miles. The system does not preclude the use of u.h.f. superheterodyne converters for receiving at greater distances. In this case it is only necessary to avoid using a first i.f. corresponding to any of the u.h.f. channels being received.

Since this system does not change the type of television receiver bought by the public, it could be rapidly introduced to provide television service for those areas which normally would have to wait a long time for conventional u.h.f. development. Also the economics of this system provide broadcasters the incentive to make television immediately available in those areas not presently covered.

Radio Navigation

(*Continued from page* 5A)

curacy of plus or minus two-tenths of a mile or 1%, whichever is greater.

Navigation by the *R*-Theta system, as it is called, involves the automatic solution of a geometrical problem in which *R* is the radius of a circle around a ground station transmitter, and theta is the angle a given radial makes with the north-south line, Fig. 4. The position of the receiver is thus fixed. DME information says the airplane is somewhere on the circumference and VOR information determines the angle.

These two pieces of information obviously constitute a fix but if the projected course does not pass over the station, navigating by this method becomes cumbersome.

R-Theta information is fed to the Course Line Computer which automatically solves the problem, giving the position of the aircraft in terms of lateral direction from the proposed track, and along-track distance to the destination.

Lateral deviation information is presented on the localizer needle of the ILS indicator. Distance information requires a special indicator.

Fig. 6 shows the basic problem involved. Several types of equipment are being developed.

Challenger-responder principle is used. Pulsed transmitter-receiver units will be carried in each airplane. When the airborne transmitter emits a pulse it is received by the ground station and caused to trigger the ground transmitter. On arrival of the pulse from the ground station at the airplane, special circuits measure the time lapse

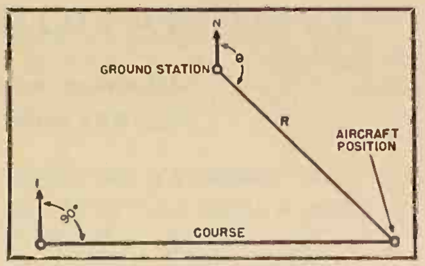


Fig. 6. The problem involved.

between the transmission of a pulse and the reception of the answer. Other circuits then translate this measurement into mechanical indication of the distance between airplane and ground station.

Since there may be more than one airplane in the vicinity of a ground station, it becomes necessary for the ground station to receive and respond to more than one signal. The resultant transmission will be a conglomeration of signals and it then becomes the responsibility of the airborne equipment to separate those signals which are responses to its transmission. The received conglomerate signal is examined stroboscopically and when a pulse is located which has a repetition rate identical to the pulses transmitted by the airplane they lock in.

There is now in the process of development for use with DME and Omni equipment, an off-schedule distance computer, which, even in its present embryonic stage can maintain a schedule over a hundred mile course with a time accuracy of plus or minus one minute. With ticket sales depending so largely on schedule maintenance, the airlines should welcome such a development with open arms.

(*To be continued*)

Fig. 7. Radio Magnetic Indicator.

1950 NATIONAL ELECTRONICS CONFERENCE

Advance program for the 1950 N.E.C. to be held Sept. 25, 26, and 27 at the Edgewater Beach Hotel, Chicago.

MONDAY, SEPTEMBER 25

1. MICROWAVES AND ANTENNAS
   - (a) "Corrugated End-Fire Antennas" by Donald K. Reynolds and Winston S. Lucke, Stanford Research Institute
   - (b) "New Techniques in Microwave Spectroscopy" by William E. Good, *Westinghouse Research Labs.*
   - (c) "Properties of Longitudinal Slots in Circular Waveguides" by G. E. Feiker and S. C. Clark, Jr., *General Electric Co.*
2. MAGNETIC AMPLIFIERS
   - (a) "Magnetic Amplifier Voltage Regulator" by John L. Wolff, *Westinghouse Electric Corporation*
   - (b) "Noise Figure of the Magnetic Amplifier" by N. R. Castellini, Signal Corps Engineering Laboratories
   - (c) "Magnetic Amplifiers with Orthonol Tape Cores" by W. A. Geyger, Naval Ordnance Laboratory
3. DIELECTRIC HEATING
   - (a) "Dielectric Load Tuning in RF Heating" by R. H. Hagopian, *Westinghouse Electric Corporation*
   - (b) "Measuring Dielectric Properties During HF Heating" by Eugene Mittelmann, Consulting Engineer
4. TIME-POSITION MEASUREMENT
   - (a) "The Electronic Umpire" by Richard F. Shea, *General Electric Company*
   - (b) "Thyratons as Close-Differential Relays" by Jordan J. Baruch, Massachusetts Institute of Technology
   - (c) "Electromechanical Pulse Delay Unit" by James F. Gordon, *Bendix Radio Company*
5. CIRCUITS
   - (a) "Miniaturizing Pentode Amplifiers by Positive Feedback" by W. B. Anspacher, Naval Ord. Lab.
   - (b) "Using Conductance Curves in Electronic Circuit Design" by Keats A. Pullen, Aberdeen Pr. Gnd.
   - (c) "Analysis of Twin-T Filters" by Louis G. Gitzendanner, *General Electric Corporation*
   - (d) "Cascading Cathode-Followers to Provide High Impedance Transformation Ratios" by Sidney E. Smith and William J. Kessler, U. of Florida
6. TUBE TECHNOLOGY
   - (a) "Electrolytic Tank Studies in Designing High Vacuum Tubes" by John E. Jacobs, Engineering Laboratory, *General Electric X-Ray Corporation*
   - (b) "A Beam-Type That Multiplies" by Alexander Somerville, Northwestern University
   - (c) "Low-Noise Miniature Pentode for Audio Amplifier Service" by R. A. Wissolick and D. P. Heacock, *RCA Victor Division*
   - (d) "Glass Selection and Production Techniques for X-Ray and Other Tubes" by J. B. Gosling, *G. E. Co.*, and M. J. Zunick, *G. E. X-Ray Corp.*

TUESDAY, SEPTEMBER 26

7. TELEVISION
   - (a) "Television in Industrial Applications" by J. A. Good, *Diamond Power Specialty Corporation*
   - (b) "Stereo Television in Remote Control" by H. R. Johnson, C. A. Hermanson, and H. L. Hull, Argonne Nat. Lab.
   - (c) "The Genlock—A New Tool for Better Programming in TV" by John H. Roe, *RCA Victor Division*
8. INSPECTION AND CONTROL
   - (a) "Reliable Electronic Equipment—A Progress Report" by G. B. Devey, Office of Naval Research
   - (b) "Detection of Tramp Metal" by C. W. Clapp, *General Electric Company*
   - (c) "Production Testing Techniques for Metallized Paper Condensers in a Telephone Network" by A. L. Bennett, *Western Electric Co.* and G.M.L. Sommerman, Northwestern U.
   - (d) "Selecting Critical Components for Matched Channel Radio Receiving Systems" by Harold D. Webb, U. of Ill.
9. EXPLORATION AND NAVIGATION
   - (a) "Recent Lorac Developments" by J. E. Hawkins, *Seismograph Service Corporation*
   - (b) "Flight Path Control" by David L. Markusen, *Minneapolis Honeywell Regulator Company*
   - (c) "Radio Interference Blanking Ahead of Receivers" by M. M. Newman, J. R. Stahmann, and Edward Svendson, Lightning and Transients Res. Inst.
10. RESEARCH INSTRUMENTATION
   - (a) "The Electron Optical System of a Permanent Magnet Electron Microscope" by John H. Reisner, *RCA Victor Div.*
   - (b) "Electronic Scanning Techniques for Low Level Circuits" by B. R. Shepard, *General Electric Co.*
   - (c) "The Point-Contact Photoconductance Cell" by George D. O'Neill, *Sylvania Electric Products Inc.*
   - (d) "A Multipurpose D-C Amplifier with Reduced Zero Offset" by Will McAdam, R. E. Tarpley, and A. J. Williams, Jr., *Leeds and Northrup*
11. COMPUTERS
   - (a) "The Study of Oscillator Circuits by Analog Computer Methods" by Han Chang, R. C. Lathrop and V. C. Rideout, University of Wisconsin
   - (b) "Rosette Principal Strain Computer" by C. M. Hathaway and R. C. Eddy, *Hathaway Inst. Co.*
   - (c) "A Versatile Small Scale Analog Computer" by James T. Carleton, *Westinghouse Electric Corp.*
   - (d) "An Electrical Analog for Indeterminant Mechanical Structures" by J. P. Corbett and J. F. Calvert, Northwestern U.
12. ELECTROACOUSTICS
   - (a) "Function of A-C Bias in Magnetic Recording" by R. E. Zenner, Armour Research Foundation
   - (b) "Recent Design Developments on Electronic Organ Tone Generators" by S. L. Krauss and C. Tennes, *C. G. Conn, Ltd.*
   - (c) "Design of Loudspeaker Enclosures" by Leo L. Beranek, Massachusetts Institute of Technology

WEDNESDAY, SEPTEMBER 27

13. OSCILLOGRAPHY
   - (a) "Progress Report on Millimicrosecond Oscillography" by Y. P. Yu, H. E. Kallman, and P. S. Christaldi, *Allen B. Du Mont Labs., Inc.*
   - (b) "A Six Channel Cathode Ray Recording Oscillograph" by Warren D. Tilton, Jr., *Hathaway Instrument Co.*
   - (c) "A Portable Projection Oscilloscope" by Victor Wouk, *Beta Electric Corporation*
   - (d) "A Cathode-Ray Oscillograph for Impulse Testing" by W. G. Fockler, *Allen B. Du Mont Labs., Inc.*
14. CONTROL INSTRUMENTATION
   - (a) "Non-linear Techniques for Improving Servo Performance" by Donald McDonald, Cook Res. Lab.
   - (b) "Electronic Control for Heating Systems" by J. M. Wilson, *Minneapolis-Honeywell Regulator Company*

(c) "Automatic Control of Inaccessible Terminal Voltages" by R. I. Cosgriff, and E. H. Gamble, *Curtiss Wright Corp.*

15. NUCLEONICS
    (a) "Electronic Aspects of Radiation Instruments" by E. E. Goodale and R. M. Lichtenstein, *G. E. Co.*
    (b) "Corona Voltage Regulator Tubes for Nucleonics" by D. L. Collins, *Victoreen Instrument Co.*
    (c) "Electronics in Particle Accelerators" by T. M. Dickinson and T. W. Dietze, *G. E. Co.*

16. INDUSTRIAL CONTROL
    (a) "Industrial Electronic Control Design Practices" by E. H. Vedder, *Westinghouse Electric Corp.*
    (b) "Electronics in Electric Power Central Stations" by A. J. Ward, *Sargent and Lundy*
    (c) "An Indirect Method of Process Control" by R. G. Durnal, *Westinghouse Electric Corporation*

17. SIGNAL GENERATORS AND ANALYZERS
    (a) "A 20 Mc. to 1,000 Mc. Sweep Oscillator" by John E. Ebert and Herbert A. Finke, Polytechnic Research and Development Co.
    (b) "A Miniature Crystal Controlled S-Band Signal Generator" by W. F. Marshall, *Bendix Radio*
    (c) "A High Resolution Spectrum Analyzer" by Theodore Miller and David S. Sims, *Westinghouse Research Labs.*

18. NUCLEONICS
    (a) "Radioactive Snow Gage with Telemetering Systems" by J. A. Doremus, *Motorola, Inc.*
    (b) "Design Characteristics of Air Proportional Counters" by A. C. Scheckler, *General Electric Company*
    (c) "An Investigation of a Scintillation Counter Using Anthracene Crystals" by Bernd Ross, *Radiation Counter Labs., Inc.*
    (d) "Hermetically Sealed High Pressure Ion Chambers" by J. G. Haines, *General Electric Company*

Luncheon speaker on Sept. 25 will be the honorable Wayne Coy, chairman of the FCC. At the Sept. 26 luncheon, E. A. McFaul of Northwestern U. will speak on "Is the Engineer Slipping?" The Sept. 27 luncheon speaker will be John V. L. Hogan, President of Interstate Broadcasting Co. and Radio Inventions, Inc. His subject is "What's Behind I.R.E.?"

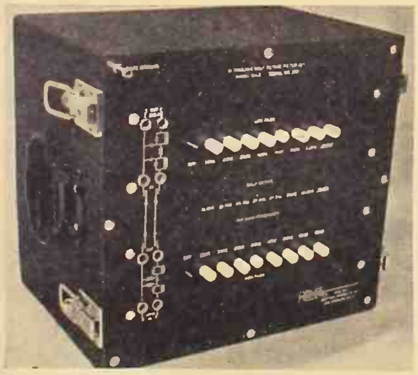
New Products

(*Continued from page* 23A)

wave, six phase. A.c. input is 220 volts, three phase, 60 cycles; delivers d.c. 24 to 32 volts, 30 amperes. The supply is continuously variable from 24 to 32 volts by rheostat control saturable reactor. Regulation is plus or minus 4% from 0 to full load and d.c. ripple, 1.5%. Ambient temperature: operates at 40°C. Convection cooled—speed of response, 0.4 seconds.

ULTRASONIC FILTER

Gertsch Products, Inc., 11846 Mississippi Ave., Los Angeles 25, California,



is now in production on its new SA-3 ultrasonic one half octave filter.

The SA-3 has a range of 10 to 160 kc. in half octave steps, and the attenuation rate is 80 db. per half octave. The minimum rejection outside the pass band is 40 db. It utilizes a passive network, without vacuum tubes and is not subject to overload. There are no beats between normal modes, and the intermodulation products are extremely low.

Loose leaf catalog sheets giving full information are available on request.

THERMOSETTING PLASTIC

Houghton Laboratories, Inc., Olean, N. Y., has available a new thermosetting plastic material for use in handling corrosive chemicals and for electrical insulation. It is reported to be inert to the corrosive action of practically all chemicals, including concentrated hydrochloric acid at room temperature, and has an exceptionally high dielectric strength with an unusually high arc resistance.

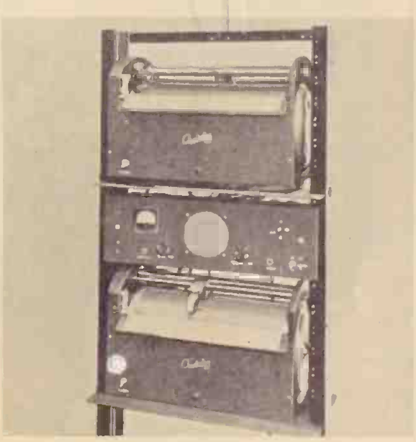
Designated Hysol 6000, this material is available in rod, tube and sheet form in a variety of sizes and may be punched or machined to close tolerances by conventional metal working machinery. It also may be cast into special shapes and components, offering unusual adhesion to metals, glass, ceramics and other materials.

Bulletin 601, which gives specifications on its chemical resistance and electrical properties, suggestions on its use, and details on its machining characteristics, may be obtained by writing the company direct.

COMMUNICATIONS RECORDER

A recording unit especially designed for logging and monitoring radio and phone communications has been announced by *Audiolog Corporation*, 440 Peralta Avenue, San Leandro, Calif.

Known as the Audiolog, this unit features the use of a thin, flexible, reusable sleeve or tube of magnetic material upon which an entire hour of speech or code communications can be recorded.



The flexible sleeves can be "telescoped" so that a 24-hour log can be filled as a compact unit. The re-usable sleeves do not deteriorate with repeated playbacks, and tests indicate they will retain the recording indefinitely.

Audiolog recorders are available in either portable or rack-mounted stationary units in single or dual type. The dual-recorder unit has automatic changeover. A small portable Audiolog using 30 minute recording sleeves is also available.

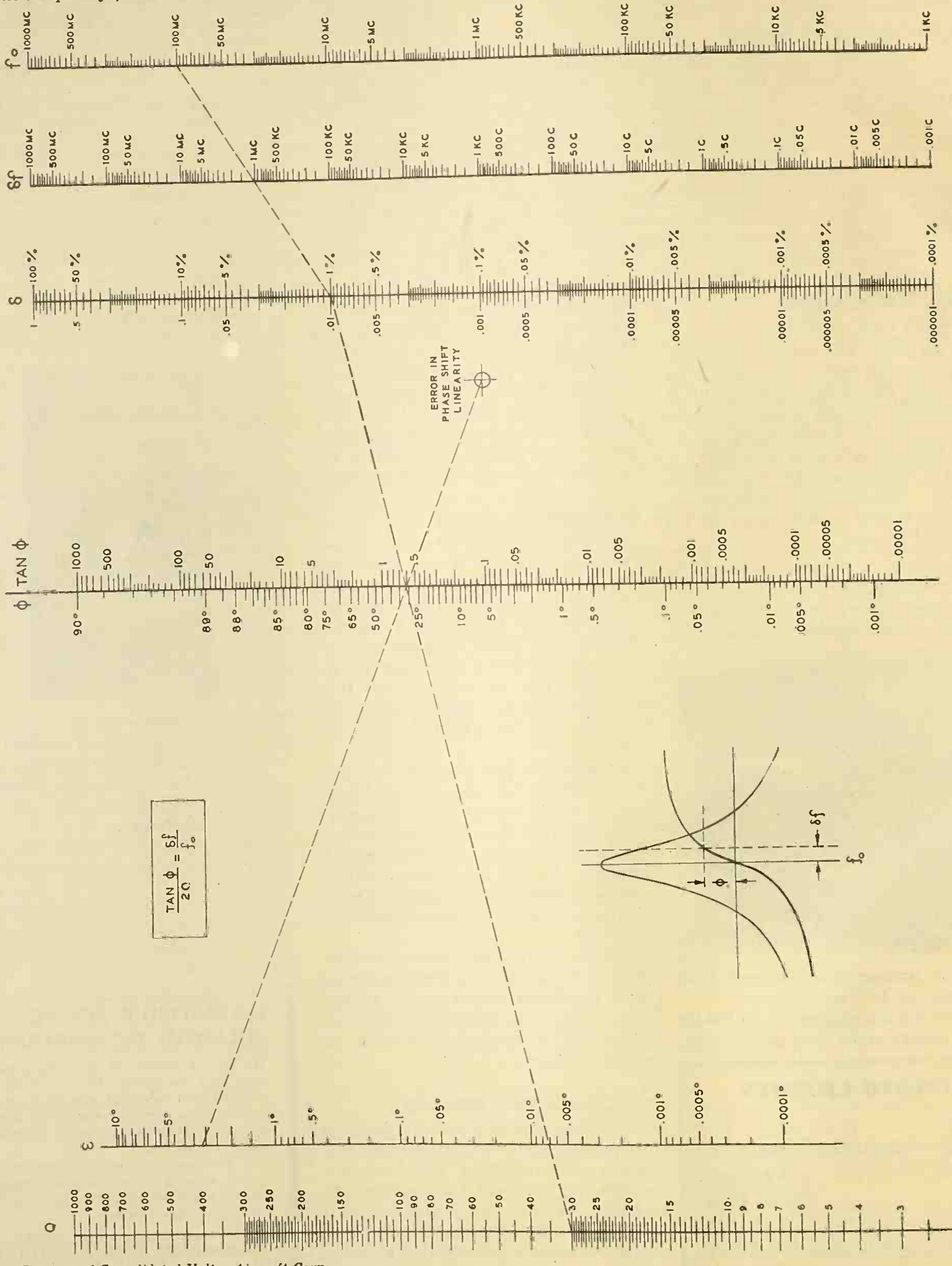
PHOTO CREDITS

Pages
3A, 4A . . . . Northwest Airlines, Inc.
6A, 28A . . . . Philco Corp.
11A . . . . Signal Corps
12A, 13A . . . . Bendix Radio Div.
15A, 18A, 27A. William Miller Corp.

OFF-RESONANCE PHASE SHIFT

By CHESTER W. YOUNG, Senior Electronic Engineer, Consolidated Vultee Aircraft Corp.

This chart enables one to determine the phase shift and the deviation from an assumed linear phase shift near the resonant frequency of a tuned circuit. The resonant frequency f_o and deviation δf are aligned to give fractional detuning δ. This point is aligned with circuit Q to give phase shift ϕ. This phase shift, aligned with the "Error in Phase Shift Linearity" point, gives error from linear phase shift on ε scale.



Courtesy of Consolidated Vultee Aircraft Corp.

NEW PROOF that RAYTHEON MEANS BUSINESS!

NOW...National Advertising to Back You at Point of Sale

Yes, Raytheon backs you up with an aggressive national advertising campaign in *Life*, *Saturday Evening Post*, *Good Housekeeping*. Over 55,000,000 people will see these hard-selling ads. Folks right in your community will read them—and want to try a new Raytheon. It adds up to easier selling for you!

Outstanding New TV Line

There's a Raytheon in every size, style and price range that your customers want. Table, console and combination models. Choice of modern and traditional styles in the most popular finishes. Choice of circular and rectangular pictures.

REPLACEMENT OR REFUND OF MONEY
Guaranteed by Good Housekeeping
IF NOT AS ADVERTISED THEREIN

Raytheon Television is backed by the Good Housekeeping Guaranty Seal—EXTRA proof of its dependability!

Don't Miss Out! Contact your Raytheon distributor today for all the facts about this profitable, popular new line. Or write us for information.

Backed by All This PROOF of DEPENDABILITY

25 RAYTHEON

WARRANTY

UL

PROOF! For over 25 years, Raytheon has pioneered and lead in radio, radar, cathode ray tubes and television.

PROOF! Backed by most liberal one-year Warranty.

PROOF! Backed by prized Underwriters' Laboratories Seal.

DEPENDABLY BUILT FOR DEPENDABLE PERFORMANCE!

RAYTHEON TELEVISION

BELMONT RADIO CORPORATION
5921 W. Dickens Ave.
Chicago 39, Ill.
Subsidiary of
RAYTHEON MFG. CO.